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ABSTRACT

This study was an attempt to provide some evidence on the effects of calculator usage with primary-age children. Specifically, the study compared the performance of children who had access to calculators for an extended period of time, and whose teachers used calculators in specified instructional ways, with children who did not have access to calculators within their daily mathematics lessons. Comparison was made on the performance on experimenter-made tests of arithmetic achievement in the areas of computation and place value. The intent was to study the effect of use of calculators within the context of the regularly used classroom curriculum. The experiment began in the first week of October 1977 with the introduction of the use of calculators by the experimenter. It ended with the final posttest administered in mid-May 1978. At the second-grade level, no statistically significant differences were noted between treatment groups except in the area of subtraction of 1-, 2-, and 3-digit numbers, where the experimental group did better. At the third-grade level, no statistically significant results were found except in the area of place value and division, where again the experimental groups did better. (Author/MK)

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Technical Report No. 502

THE EFFECT OF CALCULATOR SUPPLEMENTED INSTRUCTION UPON THE ARITHMETIC ACHIEVEMENT OF SECOND AND THIRD GRADERS

by James M. Moser

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

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Report from the Project on
Studies in Mathematics

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- developing and demonstrating improved instructional strategies, processes, and materials for students, teachers, and school administrators
- providing assistance to educators which helps transfer the outcomes of research and development to improved practice in local schools and teacher education institutions

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Table of Contents

		Page
	Acknowledgements	iv
	List of Tables	vii
	List of Figures	ix
	Abstract	xi
I.	Introduction	1
	The Call for Research	5
	Past Research	6
	The Present Study	10
II.	Description of the Study	11
	Duration of the Study	11
	Subjects	12
	The Curriculum	14
	The Calculators	18
	Instrumentation	19
	Description of the Major Tests	20
	Description of the Short Periodic Tests	23
	Experimental Treatment	25
III.	Results of the Major Tests	31
	Second Grade Results	32
	Third Grade Results	43
IV.	Results of the Short Periodic Tests	55
	Summary	73
V.	Discussion of Results	75
	Limitations	75
	Cognitive Results	76
	Affective Results	82
	Implications for Further Investigations	83

Page

References 85

Reference Note 93

Appendices

A. Copies of Tests 95

B. Specific Suggestions to Teachers on How to Use Calculator with Daily Lessons 215

C. Data Tables 241

List of Tables

Table		Page
2-1	Number of Students involved by School, Grade, Treatment and Sex	13
2-2	Chapter Headings for 1972 Revised Edition of Modern School Mathematics Structure and Use	16
2-3	Topic Titles for Developing Mathematical Processes (DMP)	17
2-4	Hoyt Reliability Estimates for Second Grade Major Subtests	22
2-5	Hoyt Reliability Estimates for Third Grade Major Subtests	24
2-6	Teachers' Estimates of Levels of Use of Calculators	30
2-7	How Calculators Were Used on Each Day of Experiment	30
3-1	Grade 2, Basic Subtraction Facts, S-F, Descriptive Statistics	34
3-2	Grade 2, Two-digit Subtraction, S-F, Descriptive Statistics	37
3-3	Grade 2, Three-digit Subtraction, S-W, Descriptive Statistics	39
3-4	Grade 2, Ordering Two-digit Numbers, S-W, Descriptive Statistics	41
3-5	Grade 3, Three-digit Subtraction, S-F, Descriptive Statistics	46
3-6	Grade 3, Place Value, S-F, Descriptive Statistics	48
3-7	Grade 3, Basic Division Facts, S-F, Descriptive Statistics	52
4-1	Mean Scores on Six-item Basic Addition Fact Tests, Second Grade Classes	56
4-2	Mean Scores on Six-item Basic Subtraction Tests, Second Grade Classes	58

Table		Page
4-3	Mean Scores on Six-item Solving Open Sentence Tests, Second Grade Class	59
4-4	Mean Scores on Three-item Addition Algorithm Tests, Second Grade Class	60
4-5	Mean Scores on Three-item 2-digit Subtraction Algorithm Tests, Second Grade Class	61
4-6	Mean Scores on 12-item Place Value Test, Second Grade Class	63
4-7	Mean Scores on Six-item Ordering Numbers Test, Second Grade Class	63
4-8	Mean Scores on Six-item Basic Multiplication Facts Test, Second Grade Class	64
4-9	Mean Scores on Six-item Addition/Subtraction Basic Facts Test, Third Grade Class	64
4-10	Mean Scores on Six-item Solving Open Addition and Subtraction Sentences, Third Grade Class	66
4-11	Mean Scores on Two-item Addition Algorithm Tests, Third Grade Class	67
4-12	Mean Scores on Two-item Subtraction Algorithm Tests, Third Grade Class	68
4-13	Mean Scores on Six-item Multiplication Facts Test, Third Grade Class	70
4-14	Mean Scores on Five-item Basic Division Facts Test, Third Grade Class	70
4-15	Mean Scores on Six-item Solving Open Multiplication Sentences Test, Third Grade Class	72
4-16	Mean Scores on Eight-item Test on Multiplication of a 2-digit Number by a 1-digit Number, Third Grade Class	72
4-17	Mean Scores on Six-item Tests (Smaller Numbers) and Twelve-item (Larger Numbers) on Place Value, Third Grade Class	74
5-1	Second Grade Results	77
5-2	Third Grade Results	80

List of Figures

Figure		Page
1	Calculator Project Weekly Log	29

Abstract

Perhaps the one area of agreement among reasonable debaters of the pros and cons of the use of hand-held calculators in schools is the need for further research on the effects of the use of calculators. The 1976 Conference on Needed Research and Development on Hand-Held Calculators in School Mathematics issued a call for an expanded information base regarding the use of calculators. This present study was an attempt to provide some evidence on the effects of calculator usage with primary age children.

Specifically the study compared the performance of children who had access to calculators for an extended period of time and whose teachers used calculators in specified instructional ways with children who did not have any access to calculators within their daily mathematics lessons. Comparison was made on the performance on experimenter-made tests of arithmetic achievement in the areas of computation and place value. The intent was to study the effect of use of calculators within the context of the regularly used classroom curriculum.

Subjects consisted of children regularly assigned to 8 classes in two schools in Madison, Wisconsin. The two schools served the same general area and were considered equivalent in terms of the population served. In each school there were two second-grade classes and two third-grade classes. One of each grade level was randomly designated as the experimental class and the other as the control. One school was implementing a "traditional" curriculum and the other was implementing the Developing

Mathematical Processes (DMP) curriculum. The two second-grade experimental classes used the Texas Instruments ABLE calculator, a four function machine with certain operations masked by means of interchangeable faces. The two third-grade experimental classes used the Texas Instruments TI-1255 calculator which is a four function machine with memory, change-sign, and percent keys. Sufficient calculators were provided so that each child had his or her own calculator.

Since the intent was to study the effects of calculator usage in connection with an ongoing program of instruction, no specially prepared software materials were used. Each teacher was given specific suggestions on how the calculator could be used in connection with daily lessons. Suggestions included checking of answers, using the calculator as an electronic "flash card" for drill of basic facts, playing games, using repeated addition/subtraction for place value and pre-multiplication and pre-division conceptual development, and simply free play or unstructured investigation. Teachers were free to use or ignore the suggestions as they chose. Teachers kept a daily log of their activities in which type of activity, duration, number of children using calculators, and mathematical content were recorded. These data were validated by means of periodic unannounced visitations by an outside observer who independently recorded similar information. Amount of usage varied from a low of 36% to a high of 79% of the number of instructional days devoted to mathematics that the calculators were used and from a low of 16% to a high of 47.5% of the number of instructional minutes devoted to mathematics instruction that some of the children were using calculators.

The experiment began in the first week of October 1977 with the introduction of the use of calculators by the experimenter. It ended with the final posttest administered in mid-May 1978. Major tests were administered in October, February, and May to all subjects. These tests covered the traditional arithmetic skills covered in second and third grades. In addition nine shorter periodic tests were administered about every three instructional weeks to selected subjects in the experimental classes. No attitudinal measures were taken.

At the second-grade level, no statistically significant differences were noted between treatment groups except in the area of subtraction of 1-, 2-, and 3-digit numbers, where the experimental group did better. When the confidence level was extended for the purpose of attempting to detect any trends in favor of one treatment group, results strongly suggested that the experimental groups at both schools performed at a higher level.

At the third-grade level, no statistically significant results were found except in the area of place value and division, where again the experimental groups did better. When the confidence level was extended for the purpose of attempting to detect any trends in favor of one treatment group, results again strongly suggested that the experimental groups performed at a higher level.

Because of the small number of classes at each grade level, it is impossible to rule out alternative hypotheses as to why the experimental groups appeared to perform at a higher level on the achievement measures used. However, it is safe to conclude that use of calculators in connection with ongoing curricula at the second- and third-grade levels had no harmful effect upon arithmetic achievement.

Chapter One

Introduction

In 1973 some preliminary investigations into the use of hand-held calculators were initiated at the Wisconsin Research and Development Center for Cognitive Learning. The calculators used at that time were simple four-function machines that were being marketed for just under $100 each. Five years later those particular machines were no longer available because they were considered to be the "Model T's" of the industry. However, analagous calculators with the same general capabilities have now become available for less that $5. This example is simply an instance of the dramatic decrease in price of electronic calculators sold in this country. Estimates suggest that around 80 million calculators have been sold and are in use today. They are priced well within the reach of every household and are no longer a status symbol for the very well-to-do.

Many of these sales are either to, or for, school age children. Also, many calculators are sold directly to schools for use in the classroom. Originally the calculator was most readily accepted at the college or university level, but has gradually found more favor with high schools and even certain elementary schools. Educators were quick to recommend imaginative uses for the calculator in the school mathematics curriculum (Bruni & Silverman, 1976; Caravella, 1977; Etlinger, 1974; Hawthorne, 1973; Hoffman, 1975; Immerzeel, 1976; Judd, 1975; Moursund, 1977).

The National Council of Teachers of Mathematics (NCTM), the leading organization for mathematics teachers, issued the following position statement early in September, 1974:

> With the decrease in cost of the minicalculator, its accessibility to students at all levels is increasing rapidly. Mathematics teachers should recognize the potential contribution of this calculator as a valuable instructional aid. In the classroom, the minicalculator should be used in imaginative ways to reinforce learning and to motivate the learner as he becomes proficient in mathematics.

At approximately the same time, the Conference Board of the Mathematical Sciences appointed the National Advisory Committee on Mathematical Education (NACOME) to prepare an overview and analysis of school-level mathematical education in the United States. While its charge was certainly broader than just to consider the use of and effects of use of calculators, the committee's report, which has come to be known as the NACOME Report, issued in November 1975, mentioned hand-held calculators in four separate places. Of special note is a major recommendation made in the final chapter:

> That beginning no later than the end of the eighth grade, a calculator should be available for each mathematics student during each mathematics class. Each student should be permitted to use the calculator during all of his or her mathematical work including tests (p. 138).

Federal agencies have also expressed interest in the issue of calculators. The Basic Skills Group of the National Institute of Education (NIE) sponsored a conference on Basic Mathematical Skills and Learning during October 1975. Known as the Euclid Conference because it was held

in Euclid, Ohio, its report consisted of two volumes--one containing 33 invited position papers and the other containing, among other things, reports of four working groups. Again, although not specifically aimed at the impact of calculators, many of the position papers and three of the four working groups explicitly mentioned calculators. In general there was a call for the realization of the many potential impacts that the calculator would have upon school mathematics programs.

In a report commissioned by the National Science Foundation (NSF) specifically to look at the impact of the calculator on precollege mathematics (Suydam, 1976) a number of interesting findings were presented. One was an analysis of positions held by people about the use of calculators in schools. The most frequently cited reasons for using calculators were:

1. They aid in computation. They are practical, convenient, and efficient. They remove drudgery and save time on tedious calculation. They are less frustrating, especially for low achievers. They encourage speed and accuracy.

2. They facilitate understanding and concept development.

3. They lessen the need for memorization, especially when used to reinforce basic facts and concepts with immediate feedback.

4. They encourage estimation, approximation, and verification.

5. They help in problem solving. Problems can be more realistic, and the scope of problem solving can be enlarged.

6. They motivate. They encourage curiosity, positive attitudes, and independence.

7. They aid in exploring, understanding, and learning algorithmic processes.

8. They encourage discovery, exploration, and creativity.

9. They exist. They are here to stay in the real world, so we cannot ignore them (p. 12).

Lest it be thought that all responses were positive, many people thought that calculators should not be used in schools. Some of their reasons were:

1. They could not be used as substitutes for developing computational skills; students might not be motivated to learn basic facts and algorithms.

2. They are not available to all, so some students are at a disadvantage.

3. They may give a false impression of what mathematics is. Mathematics may be equated to computation, performed without thinking. Emphasis is on the product rather than on the process; structure is de-emphasized. Mental laziness and too much dependence are encouraged; a lack of understanding is promoted. Some students and teachers will misuse them.

4. They are faddish. There has been little planning or research on their use in the classroom.

5. They lead to maintenance and security problem (p. 13).

In addition to these findings, a number of well thought out recommendations for curriculum and instruction were presented. Several position papers were included as appendices; these presented viewpoints expressing a need for both immediate and long range planning.

In 1977 NIE and NSF cosponsored a Conference on the Uses of Hand-Held Calculators in Education. Participants were requested to "produce a planning document that will provide a well-defined framework for future research and development efforts . . . that NSF and NIE may use if they wish as a guide to program planning." The result of the conference was a long list of recommendations for short range and long range efforts in such areas as dissemination, development of an information base, curriculum development, research and evaluation, and teacher education.

The Call for Research

As we have seen, the advent of hand-held calculators brought with it a call for creative use within classrooms. It also brought an appeal from thoughtful educators for careful research on the effects of their use. (For example, Bell, Esty, Payne, & Suydam, 1977; Etlinger, 1974.) One of the earliest and widely respected advocates of careful research has been Weaver. In a 1976 position paper he indicated that:

> The very newness of calculators provides little of a research base upon which to build . . . but by and large we have precious little information--and none of it is definitive--regarding the extent and nature of ongoing research (Weaver, 1976c, p. 18).

In the NACOME report, entitled Overview and analysis of school mathematics grade K-12 (1975), several researchable questions were listed:

> When and how should calculator use be introduced so that it does not block needed student understanding and skill in arithmetic operations and algorithms?
>
> Will ready access to calculators facilitate or discourage student memory of basic facts?
>
> For which mathematical procedures is practice with step-by-step paper and pencil calculation essential to thorough understanding and retention? (pp. 42-43)

One of the working group reports of the Euclid Conference (1975) that dealt with research priorities stated:

> . . . In particular, the potential of hand calculators must be explored. What are their innovative uses? Learning uses? What would be the long-range implications of substituting calculators for pencil-and-paper computation? (p. 29)

In the report to NSF (Suydam, 1976), these recommendations were made:

> A careful plan for systematic research should be developed.
>
> Following the above steps, appropriate research related to, and development of, curricula should be initiated (p. 41).
>
> An immediate need exists for sound and substantial research and development efforts (p. 41).

And clearly, the 1977 NIE/NSF Conference issued a mandate for further research. The conference was on "needed research and development" of hand-held calculators and school mathematics. Its report states:

> Because schooling in mathematics (not merely in computation) is important, planned research and development will be necessary in the next decade to explore a variety of options that schools may use (p. 4).

Past Research

Electronic hand-held calculators are a recent phenomenon. Prior to their advent, a number of studies were conducted using the electric desk calculator. As we shall note, these investigations have much in common with the more recent ones involving the electronic hand calculator--relatively short duration, generally carried out with upper grade or junior high school students, and often "exploratory" in nature (i.e., an uncontrolled experiment). One of the first reported was by Betts (1937) who carried out an 8-week study with 13 sixth-graders. Increased achievement and interest were reported. Fehr, McMeen and Sobel (1956) conducted a 4-1/2 month experiment with 8 classes of fifth-graders. The researchers reported that machine-taught students increased their reasoning ability and computation ability. The interest of teachers and students was also heightened by the use of the calculators.

Durrance (1965) examined the effect of the use of rotary calculators on the arithmetic achievement of 35 pairs of sixth-, seventh-, and eighth-grade students during a 9-week period. The only significant effect was upon reasoning with the seventh-graders. Broussard et al. (1969), Cech (1972), Ladd (1974) and Mastbaum (1969) conducted investigations into the use of desk calculators with slow learners at the junior high level. No significant differences were found except by Broussard et al. who found gains in achievement and attitudes. Ellis and Corum (1969) and Longstaff et al. (1968) found that use of calculators helped improve attitudes while Johnson (1971), in a short experiment, found gains in both attitudes and achievement. Gaslin (1975) in an experiment with ninth-grade general mathematics classes found that a calculator algorithm for operations on rational numbers proved to be a feasible alternative to conventional algorithms.

Around 1974, studies involving the electronic calculator began to be reported. Hohlfeld (1974) investigated the use of a programmable calculator to be used as an immediate feedback device for fifth-grade students learning basic multiplication facts. Daily drill with calculators for more than 25 class days resulted in higher achievement that drill with paper-and-pencil or other regular math activities.

Most of the first reports described informal or exploratory efforts. Bell (1976), Schafer, Bell and Crown (1975), Sullivan (1976), and Weaver (1976b), are examples of such efforts. Much of the recent work can be

characterized by the relatively short duration of the investigative efforts, lasting not much longer than a summer school session, a month, or less than 10 instructional sessions which might have been a week apart. One unreported study by the present author falls into this category as do studies by Lowerre, Veneski, and Scandura (1976), Schnur and Lang (1976), and Weaver (1976a, b), as well as a number of doctoral dissertations (Alridge, 1977; Allen, 1976; Hopkins, 1978; Hutton, 1977; Jamski, 1977; Kasnic, 1978; Nelson, 1976; Sutherlin, 1977; Whitaker, 1977).

However, several investigations have been carried out over the length of a school year. Some examples are an evaluation of a program in North York, Ontario involving fifth- and sixth-grade children (Campbell & Virgin, 1976); a year-long study with seventh-grade students in West Chester, Pennsylvania (Rudnick & Krulik, 1976); a feasability study with two sixth-grade classes in New York state Barrett & Keefe, 1974; Hawthorne & Sullivan, 1975); and a doctoral study by Quinn (1975) with eighth- and ninth-grade algebra students in a suburban St. Louis school district.

These five studies are characteristic of most of the recent research on hand-held calculators; namely, it has been carried out with older children in intermediate or junior high school grades. Grades five, six, and seven seem to be the most popular. The most notable exceptions are one exploratory study done by Weaver (1976b), a portion of the summer session feasibility study done by Scandura et al. (1976), a doctoral study carried out by Whitaker (1977), and work done in connection with

the development and field testing of the commercial program, Elementary Mathematics Concepts with Calculators, developed by Texas Instruments, Inc. (Nielsen & Loiacono, 1977).

What are the results of the research to date? The only generalization to make is that the results are mixed. Evidence indicates that the use of calculators does not harm or impede the learning of mathematics, at least as it was measured in the various studies. Despite the urging of a number of educators that calculators be used in developing problem solving skills, most studies have not examined that aspect of mathematics. This omission is understandable because of the lack of adequate measuring instruments and the short duration of most of the studies. What has been measured has been achievement in some skill area, such as decimals or addition and subtraction. In all but a few studies, achievement has been as good or better for users of calculators than for non-users. The difficulty in interpreting many of these studies, however, is that the reports indicate that calculators were used without giving sufficient information on how they were used or for how long or what percentage of instructional time.

Attitude is the other favorite variable investigated in most studies on the use of hand calculators. The consensus appears to be that children do not suffer from using a calculator; in fact, in those cases where a significant difference was reported, the advantage was in favor of the experimental groups using calculators.

The Present Study

This study was conceptualized and planned during the spring and summer of 1977 and carried out during the 1977-78 school year. At the time of planning, it intended to address three perceived weaknesses in the then current state of the art of calculator research. First, there was very little reported controlled experimentation. Most research had been informal or exploratory in nature. Second, what had been done was usually of a short term nature and did not address the question of the effect of long term usage. Third, no controlled experimentation was reported with young children at the primary grades. This was understandable because there appeared to be a fundamental axiom in most person's beliefs that calculators should not be introduced until children had learned their "basic facts" and that premature use of calculators might impede such learning. To the author, that axiom seemed unfounded and unscholarly. If it is in fact true, the truth or falsity should be determined by the results of research. Therefore this study attempts to determine the effects of use of hand-held calculators over an extended period of time upon the arithmetic achievement of second- and third-graders when the calculators are used in connection with the ongoing mathematics curriculum.

Chapter Two

Description of the Study

The major purpose of the study was to investigate the effects of the use of hand-held calculators on selected aspects of arithmetic achievement of second- and third-grade children. The calculators were used in connection with the ongoing mathematics program existing in the classrooms under investigation and the calculators were used over an extended period of time.

Duration of the Study

Initial contacts with the two participating schools were made in late spring 1977. During the first week of school in late August 1977 the principal investigator met with interested teachers at which time the nature and purpose of the investigation was explained. Agreement to participate was made and random assignment of classes to experimental or control was carried out. Pretesting of all children was done during the last week in September 1977 (about the fourth week of instruction in the 1977-78 school year). Formal work with the hand-held calculators began on October 3, 1977, with an introduction to the use of the machine by the principal investigator. The final day of the experiment was May 12, 1978 when posttests were administered. Counting released time for annual Christmas and spring vacations the use of calculators in the classroom extended over a 29-week period. The total school year lasted for 37 weeks.

Subjects

Children and teachers involved in the study were from Orchard Ridge Elementary School and Philip Falk Elementary School in Madison, Wisconsin. Madison uses the neighborhood school concept and no busing of children is carried out for racial balance purposes. What little busing there is is used to alleviate overcrowding in one or two schools. Neither of the two schools studied has busing. The neighborhoods served by the schools are adjacent to each other and are very similar. Both have a middle to upper middle class population which is almost exclusively white. There is no low-income housing and few apartments exist in these areas. Almost all homes have been built within the last 15 years.

Four intact classes were used in each school, two of each at second- and third-grade levels. The number of students in each class at the beginning of the study are indicated in Table 2-1. At Falk School all four teachers were female. At Orchard Ridge School the two experimental class teachers were female and the two control class teachers were male. All eight teachers were very experienced. Each had at least five full years of teaching experience in elementary school. The third-grade experimental class teacher at Falk School did not complete the teaching year due to pregnancy. She was replaced at the spring vacation break--the end of the 23rd week of the experiment (March 24)--by a permanent substitute who had had 4 years of full-time teaching experience.

Table 2-1

Number of Students involved by School, Grade, Treatment, and Sex

	Experimental		Control	
	Female	Male	Female	Male
Falk School				
2nd grade	10	13	11	11
3rd grade	9	12	16	10
Orchard Ridge School				
2nd grade	9	16	17	7
3rd grade	9	14	12	14

The Curriculum

The expressed intent of the study was to examine calculator effects within the context of an on-going mathematics instruction program. The calculator was used in the sense of the "calculator assisted" curriculum as characterized by Weaver (1976c). That is, the use of the calculator was desirable but not necessary. In the opinion of the writer, the full benefit of calculator use in schools will never be realized until existing curricula are modified or new ones are developed that take advantage of a calculator's distinct features. However, the necessary research associated with such modification and development will probably not be permitted by school personnel until they are convinced that use of calculators within an existing curriculum is beneficial or, at worst, of no identifiable harm. Thus, research with an existing curriculum is judged to be a necessary prerequisite for future research. Therefore, the decision was consciously made to carry out the investigation within existing curricula. The two schools participating in the study were chosen because they exemplified the use of two distinctly different curricula.

At Falk Elementary School, the program in use was the Modern School Mathematics Structure and Use, Revised Edition (1972), published by Houghton Mifflin Company. It is a classical example of what Usiskin and Bell (1976) call a "canonical curriculm," that is dominated by a concern for calculation. The overwhelming majority of work in the grade 2 materials is devoted to learning basic addition/subtraction facts and the

addition/subtraction algorithm with two-digit numbers. The grade 3 materials emphasize more addition/subtraction and then early multiplication and division skills. This particular program had been in use at Falk School for a number of years and the teachers were familiar with its content and spproach. Table 2-2 lists the chapter headings for the grade 2 and grade 3 materials.

At Orchard Ridge Elementary School, the program in use was Developing Mathematical Processes (DMP), published by Rand McNally and Company. DMP (Romberg, Harvey, Moser, Montgomery, & Dana, 1974, 1975, 1976) is an innovative program that was developed with the assistance of federal funds at the University of Wisconsin-Madison Research and Development Center for Cognitive Learning. DMP is an activity-oriented program that uses diverse manipulative materials and a variety of instructional approaches including games, stories and poems, learning stations, open-ended experiments as well as paper-and-pencil activities. Its approach is a total mathematics program that includes measurement-based arithmetic, geometry, statistics and problem-solving. While much of the arithmetic content of DMP is similar to other canonical curricula, its sequencing and its approach is different. This particular program had been in use at Orchard Ridge School for 6 years and all teachers were familiar with its content and pedagogy. DMP is a continuous progress, ungraded program built around curricular units called topics. The topics suggested for inclusion at grades 2 and 3 are listed in Table 2-3.

Table 2-2

Chapter Headings for 1972 Revised Edition of

Modern School Mathematics Structure and Use

Houghton Mifflin Company

Chapter	Grade 2	Grade 3
1	Numbers to 10; Sums to 6	Sets, numbers, numerals
2	Sums of 7-10	Addition and subtraction
3	Geometry, measurement	More about addition and subtraction
4	Sums of 11, 12, and 13; Numbers to 99	Geometry
5	Sums of 14-18	Multiplication, division by two, three, four, five
6	Addition and subtraction	Fractional numbers
7	Money/addition	More about multiplication, division
8	Geometry/fractions	Adding and subtracting with greater numbers
9	Subtraction/hundreds	Multiplying and dividing with greater numbers
10	Multiplication	Geometry
11		Addition, subtraction, multiplication, division

Table 2-3

Topic Titles for Developing Mathematical Processes (DMP)

Rand McNally and Company

Topic			
28	Symmetry, fractions, and shape	41	Movement and direction
29	Representing joining and separating situations	42	Units of weight
30	Grouping	43	Solving open sentences
31	Geometric shapes	44	Angles and symmetry
32	Solving number sentences 0-10	45	The numbers 0-999
33	The numbers 0-99	46	Comparing and ordering areas
34	Units of capacity	47	Grouping and partitioning
35	Number sentences 0-20	48	Geometric figures
36	Describing, classifying, and locating	49	The addition and subtraction algorithms, 0-999
37	Partitioning	50	Measuring length
38	Number sentences 0-99	51	Measuring time
39	Units of length	52	Investigating problems
40	The addition and subtraction algorithms, 0-99		

The Calculators

All calculators used were produced by Texas Instruments, Inc. In the two second-grade classes, the ABLE calculator was used. The ABLE is a specially designed calculator for classroom use with young children. Its primary intent was for use with a supplementary program, Elementary Mathematics Concepts with Calculators, that was also produced by Texas Instruments. The major feature of the ABLE is the interchangeability of faces. These faces had certain of the keys normally found on a calculator covered over. For example, one face designed for use with very young children had only the 0, 1, +, and - keys showing. For this experiment, the "ABLE-IV" face was used. It made the calculator a simple four-function machine with the exception that the ÷ (Division) key was covered; the decimal point key was still evident.

In the third grade classes the Texas Instruments TI-1255 calculator was used. This is a four-function machine with additional keys for %, change-sign, and four keys associated with a simple memory. Those four keys allowed one to add to, subtract from, recall, or clear memory.

In each of the experimental classes there were enough calculators provided so that each child could use his or her own machine without having to share. The calculators operated on a rechargeable battery and equipment was also provided so that recharging could be carried out at least once a week with a minimum of difficulty. Participating teachers reported no problems with recharging.

These machines did not prove to be entirely satisfactory. A surprisingly large proportion of them did not function properly for one reason or another. However, there were extra machines provided in each room so that even with the occasional malfunctioning each child was able to use a calculator when needed. A specific calculator was not actually assigned to a specific child for his or her private use. The calculators were kept in a central storage area and when one was needed, a child would use whatever calculator was available.

Instrumentation

Each test administered to the subjects was researcher-designed and was intended to measure one or more aspects of arithmetic achievement. No formal attitudinal measures were taken. Copies of all tests administered are given in Appendix A. The testing can be divided into two categories. The first consists of the major tests that were given to all students in all eight classes at three separate times. These were pretests given at the beginning of the study in September, a midyear test given in February consisting of items that were a first posttest corresponding to items given in September and items that could be considered as a second pretest of skills not covered in the first pretest, and then, the final posttest administered in May.

The second category of testing was a series of nine shorter tests administered at regular intervals of three instructional weeks. The content of these tests changed periodically to reflect the currently taught content of the classes. For each of the eight classes children were randomly assigned to one of two groups with the intention of having only

one-half of each class take these tests. This action was carried out during the period of the study with the four classes at Orchard Ridge School. However, the teachers at Falk School requested that all children be permitted to take the tests since they felt there might be some adverse effect on those children who could not take the tests. Their request was honored so that all children in all classes took all of these periodic tests.

Description of the Major Tests

Fall pretest, second grade. Identical tests were given to children in Falk School and Orchard Ridge School even though the children were in different curricula. Subtests consisted of 40 items based on basic addition and subtraction facts (3 minutes), 24 items on solving open addition and subtraction sentences with numbers 0-18 (7 minutes), and 8 items on adding and subtracting 2-digit numbers with and without regrouping (3 minutes).

Mid-year test, second grade. The first part was similar in form and timing to the fall pretest. The second part, administered on the day following the first part, consisted of three subtests. The first subtest had eight items on adding and subtracting two 3-digit numbers with and without regrouping (4 minutes). The second subtest had 18 items dealing with place value and ordering 2-digit numbers (4 minutes). The third subtest had 12 items dealing with basic multiplication facts (3 minutes). On this last subtest, notation differed for the two curricula. For the DMP children, the items were written using the DMP grouping notation of a

horizontal number sentence with parentheses [e.g., Solve the number sequence: 3 (9) = ☐]. For the children using the standard curriculum, the items were written in the more traditional vertical form with the multiplication sign [x] and the directions, "Write the Product."

Final test, second grade. This test was similar in form and timing to the midyear test. The two parts were given on two successive days.

Reliability estimates for each of the subtests on each of the tests were calculated using the split-halves method. The estimates for the second-grade tests are given in Table 2-4.

Fall pretest, third grade. Identical tests were given to children in both schools with the exception of notational differences required by the two different curricula used. The first day's testing included three subtests. They consisted of 40 items on basic addition and subtraction facts (3 minutes) (identical items to those given on the second grade pretest), 30 items on solving open addition and subtraction sentences (9 minutes) (the first 24 items were identical to those given on the second grade pretest), and 16 items on adding and subtracting two 2-digit or two 3-digit numbers with and without regrouping (5 minutes) (the 2-digit problems were identical to those on the second-grade pretest). The second day's testing also included three subtests. They consisted of 20 items dealing with place value of 2- and 3-digit numbers (3 minutes), 21 items dealing with the ordering of two or more 2- or 3-digit numbers (3 minutes), and 22 items dealing with basic multiplication and division facts (5 minutes).

Table 2-4

Hoyt Reliability Estimates for Second Grade Major Subtests

	Fall pretest		Midyear test		Spring posttest	
	Number of items	r	Number of items	r	Number of items	r
Basic addition facts	20	.92	20	.90	20	.90
Basic subtraction facts	20	.89	20	.92	20	.94
2-digit addition	4	.73	4	.81	4	.76
2-digit subtraction	4	.57	4	.65	4	.79
3-digit addition			4	.79	4	.73
3-digit subtraction			4	.62	4	.74
Solving open addition and subtraction sentences	24	.88	24	.88	24	.88
Place value			12	.89	12	.91
Ordering 2-digit numbers			6	.96	6	.96
Basic multiplication facts			12	.83	12	.83

Midyear test, third grade. The first day's testing consisted of these four subtests: 20 items on basic addition and subtraction facts (2 minutes), 18 items on solving open addition and subtraction sentences (4 minutes), 16 items on adding and subtracting two 2-digit or two 3-digit numbers with and without regrouping (5 minutes), and 20 items on place value and ordering 2-, 3-, 4-, and 5-digit numbers. The second day's testing consisted of three subtests: 6 items on adding or subtracting two 4-digit numbers (3 minutes), 10 items on basic division facts (3 minutes), and 8 items on multiplying a 2-digit number by a 1-digit number (3 minutes).

Final test, third grade. This test was similar in form and timing to the midyear test for third grade with two parts being given on two successive days. One exception was that an additional 10 items dealing with basic multiplication facts (3 minutes) were included on the second day.

As with the second grade tests reliability estimates were determined using the split-halves method. They are given in Table 2-5.

Description of the Short Periodic Tests

Nine separate tests were given during the experimental period with the first test given approximately three weeks following the commencement of the experiment. The remaining tests were administered at intervals of three instructional weeks. All tests were administered by the individual classroom teachers. No test took longer than 15 minutes to administer and the average time was about 7 minutes. The content of the

Table 2-5

Hoyt Reliability Estimates for Third Grade Major Subtests

	Fall pretest		Midyear test		Spring posttest	
	Number of items	r	Number of items	r	Number of items	r
Basic addition facts	20	.76	10	.52	10	.78
Basic subtraction facts	20	.92	10	.87	10	.81
2-digit addition	4	.71	4	.73	4	.53
2-digit subtraction	4	.58	4	.64	4	.67
3-digit addition	4	.67	4	.64	4	.59
3-digit subtraction	4	.65	4	.67	4	.64
4-digit addition/ subtraction			6	.49	6	.56
Solving open addition and subtraction sentences	30	.87	18	.84	18	.78
Place value	20	.94	16	.83	16	.81
Ordering numbers	21	.89	4	.67	4	.66
Basic multiplication facts	10	.83			10	.81
Basic division facts	12	.80	10	.80	10	.81
Multiplying 2-digit by 1-digit			8	.79	8	.80

tests varied, depending upon the subject matter that was being covered in the classes prior to the test administration. The tests consisted of items similar to those included on the major tests and each short test included several subtests, such as basic fact addition and place value or basic fact multiplication and 2-digit addition/subtraction. Once a subtest was included on a short test to determine levels of performance on a particular arithmetic skill, that subtest was included on all subsequent short tests until such time as pupil performance indicated that almost total mastery was reached. In other words, when testing showed that all students were "topping out" on a particular skill and no variation in performance was present, that subtest was dropped from all subsequent short tests. A complete analysis of results from the short tests will be given in Chapter 4 of this report; at that time characterizations of the make-up of each short test for each grade level will be presented.

Experimental Treatment

Each of the four experimental classroom teachers received detailed suggestions on how and when the calculators might be used with their ongoing curriculum. A detailed listing of those suggestions is contained in Appendix B. In general, the suggestions can be divided into several categories.

1. Checking of answers. Much of an arithmetic instructional program is devoted to children carrying out pages of computation drill or practice. Once a practice page is completed, a calculator can be used to check for

the correctness of answers. This suggestion was made frequently, although for some pages in both programs the format of the page precluded the use of the calculator.

2. As an electronic "flash card." A device frequently used by teachers to help students internalize and memorize basic computational facts is the flash card. The child, either alone or in the company of another person, responds to a visual stimulus and then turns the flash card over to verify the correctness of the response. Using a calculator, a child initiates his or her own stimulus by keying in a basic fact problem such as 5 x 7. The instruction given is to have the child verbalize the response he or she thought to be correct and then depress the [=] button on the calculator. The display given on the calculator serves the same purpose as the printed answer on the reverse side of the flash card. It is difficult, however, if not impossible, to know to what degree the subjects followed the instructions exactly. Did they personally verbalize the response before depressing the appropriate key to have the calculator display the response or did they simply key in the total sequence of buttons to give the problem and its answer? In either case it was judged that so doing would provide another instance of a visual stimulus upon a student's consciousness and awareness of a basic fact.

3. Playing a game. Two games were introduced. The first, called "Push Button," was devised by the experimenter. Two children playing against each other, choose at random a 2-digit number. The aim is to

produce that number on the calculator display with the fewest number of pushes of a calculator key. The proviso is that at least one operation key (+, -, x, or ÷) must be depressed in the sequence. Variations on the game include a restriction of the numeral keys that can be depressed, such as only the even numbered keys, or just 1, 2, 5, 7, and 8. The second game is a variation of the familiar "NIM." Two children, using a single calculator alternately, choose some target number. After starting at 0, the aim is to be the last person to press "+ x" and get the target number on the display where the number x is restricted to the binary numbers 1, 2, 4, 8, ... The domain of acceptable binary numbers varies depending upon the size of the original target number. A variation is to begin with the target number and then alternately subtract a binary number with the winner being the person who produces 0 on the display.

4. Free exploration. In this mode the children are encouraged to simply "play around" with the calculator to experiment and explore, with the hope that they might discover some mathematical content or ideas.

5. Repeated counting. The calculators employed in the experiment have the feature of the repeated addend, subtrahend, multiplier, or divisor. By using this feature, a child can, for example, count by 2's, or 5's, or 10's or any other number chosen. This feature was considered to be potentially useful in such arithmetic areas as place value or in practicing a particular set of basic multiplication facts (for example, the "fours" facts).

The teachers were given the freedom to follow the suggestions as they saw fit, to modify them, or to come up with other uses of their own invention. The degree in kind and amount to which they followed the suggestions was monitored in two ways. First, the teacher filled out a weekly log sheet (Figure 1). These sheets were filled out by all eight teachers, although the control teachers filled in only the left-hand side. Secondly, periodic unannounced visitations were made to the classrooms of the experimental teachers in order to get a sampling of calculator usage and to determine if the log sheets reported what was actually taking place.

Table 2-6 reports the estimated level of use of the calculators as reported by the teachers in their weekly logs. In reporting the use by children, teachers were also asked to describe how many children used the calculators on a given day. If at least one child used a calculator on a day, then that day was included in the total. Table 2-7 presents the frequency of use by numbers of children on each instructional day during the course of the experiment.

As Tables 2-6 and 2-7 indicate, the third grade teacher at Orchard Ridge School tended to use the calculators to a much greater extent than the other three experimental teachers.

The visitations by the outside observer generally confirmed the data supplied by the teacher. The percentage of calculator use on the observational days tended to be slightly higher than the overall percentages reported by the teachers. Perhaps the teachers thought that the observer may have wanted to see calculators being used and therefore altered their teaching plans accordingly.

CALCULATOR PROJECT WEEKLY LOG

Week of _____ Teacher _____

Day	Date	Time Begin	Time End	Pages or Activity done	Did you use suggestions?	CALCULATOR USAGE: Estimate of time calculators used	CALCULATOR USAGE: Estimate of number of children using calculators
Monday					Yes / No	0 5 10 15 / 20 25 30 35 / 40 45 50 55	all / more than half / less than half / 1 - 5 / none
Tuesday					Yes / No	0 5 10 15 / 20 25 30 35 / 40 45 50 55	all / more than half / less than half / 1 - 5 / none
Wednesday					Yes / No	0 5 10 15 / 20 25 30 35 / 40 45 50 55	all / more than half / less than half / 1 - 5 / none
Thursday					Yes / No	0 5 10 15 / 20 25 30 35 / 40 45 50 55	all / more than half / less than half / 1 - 5 / none
Friday					Yes / No	0 5 10 15 / 20 25 30 35 / 40 45 50 55	all / more than half / less than half / 1 - 5 / none

Figure 1. Calculator Project Weekly Log

Table 2-6

Teachers' Estimates of Levels of Use of Calculators

Teacher	% of instructional days	% of instructional minutes	Average minutes/day when calculator used
Orchard Ridge 2	36.0	15.6	14.3
Orchard Ridge 3	79.1	47.5	21.4
Falk 2	42.8	30.1	23.4
Falk 3	47.1	20.4	19.0

Table 2-7

How Calculators Were Used on Each Day of Experiment

Teacher	Number of children using calculator					Total instructional days during experiment
	All	More than half	Less than half	1 to 5	None	
Orchard Ridge 2	18	13	5	9	86	131
Orchard Ridge 3	30	32	16	28	28	134
Falk 2	23	25	6	3	76	133
Falk 3	15	23	11	8	66	123

Chapter Three

Results of the Major Tests

All students in the experimental and control classes of both schools at the second and third grade level were tested three times. These tests occured immediately prior to the beginning of the study in the last week of September 1977, midway through the study in early February 1978, and, finally, at the end of the study in mid-May 1978. The tests consisted of a number of subtests. The results of these subtests will be reported in the present chapter. Because the number of items on the various subtests differs from test to test, all scores have been converted to percentages to facilitate comparison of results.

A simple one-way analysis of variance was used to test for any differences in results between experimental and control classes. Because the curriculum varied so greatly in emphasis and sequencing between the two schools, any comparisons for school effects are meaningless and therefore not presented. Some might conjecture possible differences between boys and girls by reason of a hypothesized preference by boys for mechanical devices such as calculators. The author believes that such a hypothesis is unfounded and based on an antiquated sexist bias. Analysis of differences between the sexes has confirmed this feeling since absolutely no significant differences between boys' and girls' performance on any measure were evident.

In an attempt to control for any possible initial differences between classes, change scores were computed for each child on each subtest. The change scores were then subjected to the analysis of variance. In the sections that follow these abbreviations will be used:

S - F: the difference or change in performance between the spring administration of a subtest and the fall administration.

W - F: the difference or change in performance between the winter (or midyear) administration of a subtest and the fall administration.

S - W: the difference or change in performance between the spring administration of a subtest and the winter (or midyear) administration.

Data tables for each grade level and for each subtest analysis are given in Appendix C. Whenever a particular statistical comparison may suggest some interesting potential differences between experimental and control classes, the appropriate data will be presented in this chapter. Results for second grade classes will be presented first with third grade results following. Descriptions of the actual tests are given in Chapter 2 and the actual tests themselves are presented in Appendix A.

Second Grade Results

Basic addition and subtraction facts. A great portion of instructional time in both schools was devoted to instruction in the basic facts. As might be expected, a noticeable growth in performance was detected

over the period of the experiment in all four second grade classes. This growth was evident in both addition and subtraction with greater growth occurring in subtraction than in addition. The reason for this is that initial performance in late September was much lower for subtraction, thus leaving greater potential for growth. In contrasting the mean S - F scores between experimental and control groups for the combined basic facts, a potential significant difference in favor of the experimental group was detected ($F = 2.79$, df 1/83, $p = .098$). Upon closer examination no differences were found for the addition change scores. However, the differences in basic fact subtraction change scores were significant. Table 3-1 presents the descriptive statistics as well as the analysis of variance. The F statistic of 2.84 for the Orchard Ridge School is not quite large enough to support a definitive statement of highly probable significant difference. However, its associated p value is sufficiently small to suggest that the significant difference for the combined classes is not solely attributable to the Falk School experimental class.

As a matter of interest, the mean W - F (fall semester) change scores and the mean S - W (spring semester) change scores indicate that the largest amount of gain in subtraction occurred in the fall semester at Falk School while at Orchard Ridge the amount of gain was fairly consistent over the entire school year. These results are probably indicative of the differing curricular emphases at the two schools.

Table 3-1

Grade 2
Basic Subtraction Facts
S-F

Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	46	.755	.263	22	.886	.231	24	.635	.234
	Control	44	.691	.289	21	.792	.213	23	.599	.321
F	Experimental	43	.310	.205	18	.363	.231	25	.271	.179
	Control	46	.391	.223	22	.456	.168	24	.331	.253
S-F	Experimental	41	.421	.247	17	.486	.236	24	.373	.249
	Control	44	.294	.217	21	.338	.194	23	.254	.233

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	10.732	1	10.732	199.30		6.247	1	6.247	137.12		4.658	1	4.658	80.04	
Groups	.339	1	.339	6.30	.014	.212	1	.212	4.65	.038	.165	1	.165	2.84	.099
Within Groups	4.469	83	.054			1.640	36	.046			2.619	45	.058		
Total	15.541	85				8.010	38				7.442	47			

Solving open addition and subtraction sentences. Work with solution of open sentences occurs in both curricular programs used at the two schools. However, the timing, sequence, and purpose of this work differs greatly. An initial examination of the analysis of variance results ($F = 5.43$, df 1/83, $p = .022$) suggests a significant difference in favor of the experimental classes. However, this difference is not consistent across both experimental classes. In fact, at the Falk School the difference in mean change scores, while not being significant, favors the control group while at Orchard Ridge School the difference in favor of the experimental group is highly significant ($F = 14.20$, df 1/47, $p = .0005$). Further examination reveals that the most significant change occured during the spring semester. Such facts strongly suggest that what differences do exist are not uniform across classes, are probably not due to any calculator effect but rather are due to the effect of the curricular emphasis of the teacher in the experimental class at Orchard Ridge School.

Addition and subtraction of 2-digit numbers. The development of addition and subtraction skills with 2-digit numbers receives major attention in the second half of most second grade curricula. Teacher logs indicate that at Falk School this was indeed the case. However, at Orchard Ridge School the teachers of both the experimental and control classes indicated that no formal instruction took place during the duration of the experiment. However, the data do indicate that a substantial amount of growth did take place over the entire year and that a significant difference in favor of the experimental group was evident ($F = 5.69$, df 1/83, $p = .019$). As was the situation with basic facts, almost all of this

difference was traceable to differences in subtraction. In fact, the F ratio for differences in change scores for addition was .00. The data for subtraction over the entire S - F period are presented in Table 3-2. As the data indicate, the differences in favor of the experimental classes are consistent across both schools. The extremely low scores for the Orchard Ridge School in the fall administration indicate that most children simply did not attempt the test items.

Examination of the W - F (fall semester) and S - W (spring semester) change scores do not reveal any particular pattern of growth for all classes. Some improved more in the fall and others more in the spring; still others demonstrated equal growth over the entire year. Once again, this phenomena probably reflects the curricular emphases of the particular teachers involved.

Addition and subtraction of 3-digit numbers. Adding and subtracting 3-digit numbers receives very little, if any, curricular attention in the second grade. However, in the interest of trying to detect any transfer of skills, the children were tested at midyear and again at the end of the experiment. This yielded a single gain score comparison, S - W. Even though little or no instruction took place, performance was remarkably high. The same pattern with addition/subtraction of 1- and 2-digit numbers appeared in this subtest. The F statistic for the analysis of variance ($F = 29.66$, df 1/84, $p = .000$) was highly suggestive of a significant difference in favor of the experimental classes. Looking at

Table 3-2

Grade 2
Two-digit Subtraction
S-F

Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	46	.625	.328	22	.829	.260	24	.438	.268
	Control	44	.398	.351	21	.595	.279	23	.217	.314
F	Experimental	43	.151	.212	18	.333	.210	25	.020	.070
	Control	46	.185	.238	22	.296	.227	24	.083	.204
S-F	Experimental	41	.457	.256	17	.515	.257	24	.417	.252
	Control	44	.216	.283	21	.310	.284	23	.130	.260

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	9.389	1	9.389	128.56		6.120	1	6.120	82.46		3.596	1	3.596	55.00	
Groups	1.237	1	1.237	16.94	.0001	.396	1	.396	5.33	.027	.962	1	.962	14.72	.0004
Within Groups	6.062	83	.073			2.672	36	.074			2.942	45	.065		
Total	16.688	85				9.188	38				7.500	47			

addition separately, a seemingly significant difference was attributable only to a large difference in favor of the experimental class at Orchard Ridge School. In fact, at Falk School the difference was negligible but slightly in favor of the control class. However, for subtraction the difference in favor of the experimental classes was consistent across both classes. The data for the S - W subtraction are presented in Table 3-3.

On examination of the results, one must take note of the extremely low performance for the winter administration in the experimental class at Orchard Ridge. Whether such scores are a true reflection of the ability being measured or whether they are a result of some aberrant condition present during testing is difficult to determine from the data themselves. Therefore, the gain score which accounts for a sizeable portion of the overall difference may in reality be a spurious one. Logical conclusions about potential effects due to the experimental treatment must be made with caution.

Place value of 2-digit numbers. This numeration concept tends to be covered in the latter half of second grade. Consequently, the decision was made to test only at midyear and at the end of the study. As a result, only one change score, S - W, was subjected to analysis. The extremely low F value of .02 indicated no differences of any kind between one group and the other. The relatively high scores achieved by all students at the end of the experiment indicate that place value is a well understood concept by the students of this study. No marked differences were evident from one school to another.

Table 3-3

Grade 2
Three-digit Subtraction
S-W
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	48	.573	.282	23	.717	.285	25	.440	.208
	Control	42	.345	.307	21	.476	.249	21	.214	.309
W	Experimental	47	.255	.230	22	.421	.142	25	.110	.192
	Control	40	.344	.264	21	.429	.161	19	.250	.323
S-W	Experimental	47	.324	.280	20	.318	.269	25	.330	.295
	Control	37	-.020	.285	20	.050	.299	17	-.103	.251

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	2.503	1	2.503	31.40		1.524	1	1.524	18.91		1.006	1	1.006	12.99	
Groups	2.460	1	2.460	30.86	.000	.753	1	.753	9.35	.004	1.897	1	1.897	24.49	.000
Within Groups	6.537	82	.080			3.223	40	.081			3.098	40	.077		
Total	11.500	84				5.500	42				6.000	42			

Ordering of 2-digit numbers. The skill of ordering 2-digit numbers is dependent to a certain degree upon the knowledge of the place value associated with those numbers. A student would not do well on ordering 2-digit numbers until he or she had had some formal instruction on 2-digit numbers. In fact, in most programs, ordering of 2-digit numbers is part of the overall instruction dealing with 2-digit numbers and their place value. Again, since formal instruction did not occur until the latter half of the second-grade school year, testing was carried out only at midyear as a pretest and at the end of the experiment as a posttest. Consequently, as was the case with place value, only one change score, S - W, was subjected to analysis. Contrary to the place value results, a surprisingly large F value (F = 13.14, df 1/84, p = .001) was computed, with the difference in favor of the control groups. Data are presented in Table 3-4.

Inspection of the data suggests two hypotheses that may explain the highly significant difference that resulted. First, the very high performance level on the posttest (S scores) indicates that a ceiling effect was present, particularly for the experimental groups who performed rather well on the pretest (W scores). Secondly, there were rather sizeable differences between the experimental and control group performances on the pretest. Such large initial differences were generally not present on other subtests. In other words, initial performance scores may well have been inordinately high or low due to some chance factor. If so, then the

Table 3-4

Grade 2
Ordering Two-digit Numbers
S-W
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	48	.937	.205	23	.942	.211	25	.933	.042
	Control	42	.877	.297	21	.952	.094	21	.802	.400
W	Experimental	47	.840	.293	22	.788	.357	25	.886	.219
	Control	40	.512	.482	21	.563	.476	19	.456	.496
S-W	Experimental	47	.096	.299	22	.152	.304	25	.047	.291
	Control	37	.410	.490	20	.408	.485	17	.412	.511

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	4.606	1	4.606	29.64		3.149	1	3.149	14.06		1.589	1	1.589	10.25	
Groups	2.042	1	2.042	13.14	.0005	.691	1	.691	4.31	.044	1.348	1	1.348	8.69	.005
Within Groups	12.742	82	.155			6.410	40	.160			6.203	40	.155		
Total	19.390	84				10.250	42				9.140	42			

regression effect could account for a portion of the large growth on the part of the initially lower control group as well as for part of the small growth on the part of the initially high experimental group.

Basic multiplication facts. Basic multiplication facts receive little attention in second grade. While they are usually present in text materials near the end of the books, frequently the subject is omitted for lack of time. Data received from participating teachers indicated that such was the case with the children involved in the study. Data collected in mid-year and at the end of the study supported this conclusion. Initial performance was uniformly low for all four classes. Data collected at the end of the study showed that very little gain was made in performance and whatever gain was made was not significantly different for either group.

Summary. Complete data tables for all the analyses of change scores for second grade are presented in Appendix C. Where the differences in change scores appeared to be significant, results were presented in detail in this section. All change scores were compared and differences in favor of one group over the other for combined classes and for each school separately were tabulated. The overall trend of significant (statistically) and nonsignificant differences was strongly in favor of the experimental classes that used the calculator.

Third Grade Results

Before proceeding with a discussion of each of the major subtest results for third grade, a brief statement concerning a slight disruption of testing conditions must be presented. In addition to the major tests there was a sequence of shorter tests given every 3 weeks. To control for any possible testing effects, the decision was made to test only a randomly selected half of each class. This plan was carried out at the Orchard Ridge School. Unfortunately, the control class teacher became slightly confused during the final major testing at the end of the experiment. Although tests were provided for all students with the students' names written on the tests, he thought that the tests should still be given to only the half of the class that had been given the 3-week tests. This error was not immediately detected until it was too late to test the half of the class that had missed the final posttesting. Thus, data on the final testing for that one class exist for just half the class. Subsequent analyses were made on all data existing for the entire class--i.e., the F (or initial pretest) and the W (midyear testing) data, comparing the two randomly selected halves of the class. The intent was to determine if the random selection had indeed determined two groups that were roughly equivalent. No significant differences on any measure were present, suggesting that the two halves were generally equivalent.

Basic addition and subtraction facts. While the bulk of instruction on this topic occurs in second grade, it is well known that third grade teachers will carry out systematic review, drill, and practice in order

to bring children up to an almost 100% level of mastery. Judging from the test results, effective instruction at both schools had been carried out. Very high levels of performance were evident from the pretest. By mid-year and by the end of the experiment, the ceiling effect was evident. Consequently, no differences between groups were detected.

Solving open addition and subtraction sentences. The data for this subtest suggest that very little instruction was devoted to this topic over the duration of the experiment. Mean change scores for combined groups was only 7% for the experimental group and only 1% for the control group. In fact, at one of the schools the mean change score for the S - F period was a negative number, indicating no growth at all or even a slight loss. While the F statistic ($F = 3.60$, df 1/76, $p = .062$) is mildly suggestive of a statistically significant difference, the actual miniscule change on the part of both groups makes any further discussion trivial.

Addition and subtraction of 2- and 3-digit numbers. These skills receive a considerable amount of attention, particularly in the first half of the third-grade year. Records received from the teachers about what they taught support this judgement. Examination of mean change scores during the S - F period indicates that considerable growth in these skills took place. The overall change score comparisons produced an F statistic ($F = 6.68$, df 1/76, $p = .012$) that indicated further analysis was warranted. Thus analysis of change scores for addition and subtraction was carried out separately for both 2- and 3-digit numbers. Addition of 2-digit numbers produced no significant differences; in fact, the ceiling effect seemed

to be present. Overall performance on addition of 3-digit numbers was not as high but, again, no significant differences were evident. Turning to subtraction of 2-digit numbers, the expected pattern of considerable growth during the S - F period was clearly evident. The F statistic (F = .096, df 1/76, p = .096) was suggestive of a potential significant difference in favor of the experimental groups. However, most of this difference could be attributed to a sizeable difference in only one of the two classes studied. Thus, no further analysis was carried out. However, subtraction of 3-digit numbers produced a highly significant difference in favor of the experimental group. The data are presented in Table 3-5.

Examination of the data indicates that the direction of change was consistent across both classes and that perhaps the reason for the difference in favor of the experimental classes was the experimental treatment. However, further examination of the change pattern over the entire period of the experiment yielded some results that make any conclusions highly tenuous. The changes during the W - F (fall semester) and S - W (spring semester) periods were examined. For the Falk School classes, the growth was orderly and systematic. During each period the experimental and control groups showed growth, the experimental group showing a greater, though not significantly different, growth each period. As Table 3-5 indicates, the cumulative effect for the S - F period produced a statistically significant different in favor of the experimental class. On the other hand, the data from the Orchard Ridge School is open to serious question.

Table 3-5

Grade 3
Three-digit Subtraction
S-F

Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	44	.881	.191	21	.881	.187	23	.880	.198
	Control	38	.737	.318	25	.760	.302	13	.692	.356
F	Experimental	42	.310	.240	21	.452	.150	21	.167	.228
	Control	44	.375	.288	22	.523	.266	22	.227	.230
S-F	Experimental	42	.566	.303	21	.429	.226	21	.702	.312
	Control	34	.294	.424	21	.191	.362	13	.462	.477

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	14.988	1	14.988	114.44		4.024	1	4.024	44.33		12.664	1	12.664	86.53	
Groups	1.384	1	1.384	10.56	.002	.595	1	.595	6.56	.014	.466	1	.466	3.18	.084
Within Groups	9.691	74	.131			3.631	40	.091			4.683	32	.146		
Total	26.063	76				8.250	42				17.813	34			

During the W - F (fall semester) both classes showed growth but the control class growth was extraordinarily high, well beyond normal expectation. The W (or midyear test) mean performance for the control class was 89.6%. The fact that the final spring test performance was 20% lower indicates that something irregular may well have occurred during either the testing sessions or during the classroom instruction carried out in that class. The fact that only half the class took the final posttest in the spring may well account for some of the unexpected results. By contrast, the experimental class at Orchard Ridge School exhibited the general pattern of consistent growth that was evident in both the Falk School classes. As a result of the aberration in the Orchard Ridge School control class data, no claims can be made for the efficacy of the experimental treatment as far as this subtest is concerned.

Addition and subtraction of 4-digit numbers. Computation with larger numbers is not usually taught in third grade. The decision to test at midyear and in the spring was simply to see if any transfer of a known skill to a similar but slightly more difficult skill was taking place and if using the calculator made any difference. Very surprising results were noticed--there was an unexpectedly high level of performance across the board on the pretest. When posttested in the spring, three of the four classes showed little or no growth. The fourth class, the experimental class at the Falk School, which was the lowest of the four to begin with, made the greatest gain, ending up with the largest mean achievement score in the spring. However, the overall result was that no significant differences were noted and certainly nothing that could be attributed to the experimental treatment.

Place value of 2- and 3- digit numbers. While place value is important in the development of computational algorithms, the tendency of instructional programs is to give it a fairly light treatment. Yet children appear to do well on tests dealing with place value. For the third grade classes in this study, this seemed to be true. However, the data indicate that the experimental classes performed substantially better. Table 3-6 presents the overall data.

While the trend favoring the experimental classes appears to be consistent across both classes, closer inspection of the data also indicates that the majority of the overall effect is due to the results of the Falk School classes. The mean negative change score for the control classes from the fall administration to the spring is close to zero, indicating that essentially no growth occurred during the course of the experiment. Considering the midyear score for the Falk School control class, the performance was actually very stable across all three test administrations. This fact tends to rule out the high possibility of a regression effect being present. The tentative conclusion is that the children in this one class did not grow in that particular skill over the year. The most reasonable explanation is that the subject was not part of the teacher's instructional program. The initial high performance suggests that perhaps some pre-assessment of the class was made and in the teacher's judgement, no additional formal instruction was needed. On the other hand, the presence of growth in all three other classes indicates that the teachers

Table 3-6

Grade 3
Place Value
S-F

Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	44	.855	.197	21	.827	.197	23	.880	.199
	Control	38	.661	.338	25	.692	.316	13	.601	.382
F	Experimental	41	.559	.299	20	.592	.263	21	.528	.334
	Control	52	.531	.340	26	.703	.299	26	.359	.291
S-F	Experimental	41	.287	.245	20	.230	.208	21	.341	.270
	Control	38	.054	.224	25	-.019	.167	13	.194	.258

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	Combined SS	df	MS	F	p	Falk SS	df	MS	F	p	Orchard Ridge SS	df	MS	F	p
Mean	2.413	1	2.413	43.61		.378	1	.378	10.92		2.757	1	2.757	39.06	
Groups	1.072	1	1.072	19.37	.000	.689	1	.689	19.92	.000	.174	1	.174	2.46	.126
Within Groups	4.260	77	.055			1.488	43	.035			2.259	32	.071		
Total	7.745	79				2.555	45				5.190	34			

of those classes did include instruction on place value at some time in their program. Since the sizeable difference between the two Falk School classes did account for most of the overall difference, the safest conclusion regarding the overall difference is that it probably occurred due to a teacher effect.

Ordering of 2- and 3-digit numbers. As indicated in the discussion of the second-grade results, this topic goes hand-in-hand with place value instruction. While some growth was detected in all classes, no significant differences in the size of the growth were observed.

Basic multiplication facts. This topic generally receives a very sizeable amount of attention in third-grade mathematics instruction. Because of the curricular dissimilarities between the two schools, the amount of instructional time allotted to the basic multiplication facts differed in the two schools. In each school the differences between the experimental and control class mean change scores were significant. However, in one school it favored the control class and in the other school it favored the experimental class. Consequently, these effects tended to cancel each other out and produce no significant difference for the overall or combined groups. It is safe to say that differences which did occur between classes reflect the curricular emphasis placed on basic facts by the respective teachers.

Basic division facts. Learning of basic division facts tends to accompany instruction in basic multiplication facts, although division comes

later in the instructional sequence. Curricular differences between the two schools cause the manner, notation, and sequencing of division to be different. As a result, while the numbers in the tests administered to the two schools were the same, the format of the tests were different. Even though division is not covered during the early part of the school year, the basic division facts were tested at all three test administrations. As might be expected, initial performance levels were quite low. Yet, considerable growth occurred during the year as evidenced by the amount of change. For this particular area of mathematical content, the test data indicated a highly significant difference in favor of the experimental classes. Data are given in Table 3-7.

The data appear to be fairly regular in that no substantially large initial differences were present and that the direction of difference was consistent across both schools. Though not included in Table 3-7 the data collected on amount of growth during the W - F (fall semester) and S - W (spring semester) periods confirmed the observation made above. The greater proportion of growth did take place during the spring semester. Because the division symbol (÷) does appear on the calculator keyboard and is a novelty to curious students who have not previously encountered it in their studies, it does seem to be a plausible hypothesis that the experimental treatment may account for the significant difference in the change scores of the two groups.

Table 3-7

Grade 3
Basic Division Facts
S-F
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	43	.746	.266	21	.800	.274	22	.695	.253
	Control	38	.613	.280	25	.683	.295	13	.476	.192
F	Experimental	41	.290	.209	20	.300	.184	21	.281	.235
	Control	52	.299	.230	26	.397	.251	26	.202	.158
S-F	Experimental	40	.461	.259	20	.510	.275	20	.413	.239
	Control	38	.282	.259	25	.284	.282	13	.278	.217

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	10.903	1	10.903	162.70		6.643	1	6.643	85.32		4.271	1	4.271	80.21	
Groups	.629	1	.629	9.39	.003	.568	1	.568	7.30	.010	.144	1	.144	2.70	.111
Within Groups	5.093	76	.067			3.348	43	.079			1.651	31	.053		
Total	16.625	78				10.560	45				6.065	33			

Multiplication of a 2-digit number by a 1-digit number. This more advanced multiplication skill is introduced during the latter half of third grade in most traditional curricula. In the experimental DMP curriculum used at Orchard Ridge, it is not presented at all in the form in which it was tested. Simpler, developmental lessons leading up to this skill are given in the DMP materials, however. In other words, the children in that school would see the problem as one of repeated addition rather than as a combination of previously learned multiplication and place value skills. At any rate, because of its late introduction, tests were administered only at midyear and at the end of the experiment. Although a significant difference in favor of the experimental class was noted at one school, no overall effect for combined groups was present. Therefore, the judgement is made that the experimental treatment did not produce any significant differences.

Summary. Complete data tables for all the analyses of change scores for third grade are presented in Appendix C. This section presented those data where the differences in change scores appeared to be significant. A summary of all change scores that tended to indicate a favoring of one group over the other was made. In some instances, the difference was statistically significant and in the others the difference was strongly suggestive of a possible advantage of one group over the other. In all of those instances that were summarized, the great majority of them were in favor of the experimental groups over the control groups.

Chapter Four

Results of the Short Periodic Tests

The shorter tests were administered at regular intervals of three instructional weeks throughout the study. Copies of the tests are presented in Appendix A. The content of the tests varied throughout the year in an attempt to reflect, to some degree, the content of instruction as it was being carried out. In other words, a particular objective was not tested until approximately the time it was scheduled to be covered. Once items testing a specific skill were introduced on the short test, they were maintained on subsequent tests until evidence demonstrated student mastery of the skill.

Second grade results will be presented first. Many of the data will show some upward and downward fluctuation from one test administration to another. This is attributable to the short length of the tests. Even though randomization of problem difficulty was followed, there were times when one test proved to be slightly easier or harder than others.

Basic addition facts. Table 4-1 presents mean scores on the seven separate administrations. The general pattern is one of growth, although the XR class does show more fluctuation. The overall picture is that these data probably reflect quite closely the instruction that was carried out.

Table 4-1

Mean Scores on Six-item Basic Addition Fact Tests
Second Grade Classes

Class	Administration date						
	10/21	11/10	11/30	12/20	1/24	2/16	3/6
XF	5.3	5.8	5.8	5.7	5.6	6.0	6.0
CF	5.7	5.7	5.9	5.9	5.8	5.9	5.7
XR	4.9	5.2	5.6	5.2	4.7	4.5	5.4
CR	5.2	4.9	5.6	5.5	5.1	5.7	5.7

Note. XF - Experimental Class, Falk School
CF - Control class, Falk School
XR - Experimental class, Orchard Ridge School
CR - Control class, Orchard Ridge School

Basic subtraction facts. Table 4-2 presents mean scores on the seven separate administrations. The data are similar to the addition basic facts in that the general trend is one of growth. As expected, the level of achievement is somewhat lower for subtraction than addition. The data also suggest that less time was given to basic fact instruction and practice at Orchard Ridge School than at Falk School.

Solving open addition and subtraction sentences. Table 4-3 presents mean scores on the nine separate administrations. The growth suggested by the Orchard Ridge School data is more substantial than that of Falk School. This simply indicates again how the short tests reflect the emphasis of classroom instruction. In the DMP program used at Orchard Ridge, solving open sentences receives a great deal of attention, more so than that given in the program used at Falk School.

The addition algorithm. Table 4-4 presents data for the five administrations of a test on 2-digit addition and for the two administrations of a test on 3-digit addition. Here the data clearly indicate differences in the emphasis of instruction. In fact, at Orchard Ridge no formal instruction of any kind was given in use of the addition algorithm.

The two-digit subtraction algorithm. Table 4-5 presents data on the five separate administrations of a 3-item test. Results from the first several administrations indicated that it would be fruitless to test the children on the 3-digit subtraction algorithm. Comparison of these data with those of Table 4-4 confirm the expected result that

Table 4-2

Mean Scores on Six-item Basic Subtraction Tests
Second Grade Classes

Class	Administration date						
	10/21	11/10	11/30	12/20	1/24	2/16	3/6
XF	5.2	5.1	5.5	5.7	5.3	5.0	5.8
CF	5.5	4.8	5.5	5.2	5.7	5.5	5.3
XR	4.9	3.8	3.8	4.3	3.8	3.1	4.6
CR	3.8	3.9	3.6	4.3	4.7	5.0	5.0

Note. XF - Experimental class, Falk School
CF - Control class, Falk School
XR - Experimental class, Orchard Ridge School
CR - Control class, Orchard Ridge School

Table 4-3

Mean Scores on Six-item Solving Open Sentence Tests
Second Grade Class

	Administration date								
Class	10/21	11/10	11/30	12/20	1/24	2/16	3/6	3/23	4/21
XF	4.0	4.1	4.6	5.0	4.5	5.4	5.0	4.8	4.4
CF	4.1	3.9	5.0	4.7	4.7	5.3	4.7	4.7	5.0
XR	2.5	3.0	3.3	2.5	3.8	2.6	3.4	3.9	4.8
CR	3.3	3.0	3.2	2.8	3.9	4.1	4.4	4.9	4.8

Note. XF - Experimental class, Falk School
CF - Control class, Falk School
XR - Experimental class, Orchard Ridge School
CR - Control class, Orchard Ridge School

Table 4-4

Mean Scores on Three-item Addition Algorithm Tests
Second Grade Class

Class	Administration date						
	1/24	2/16	3/6	3/23	4/21	3/23	4/21
			2-digit			3-digit	
XF	1.8	2.3	2.1	2.1	2.5	1.8	2.4
CF	1.3	1.5	1.8	1.8	2.5	1.2	1.8
XR	0.8	1.2	1.3	1.1	1.2	1.1	1.1
CR	1.3	1.3	1.9	1.6	1.5	1.4	1.2

Note. XF - Experimental class, Falk School
CF - Control class, Falk School
XR - Experimental class, Orchard Ridge School
CR - Control class, Orchard Ridge School

Table 4-5

Mean Scores on Three-item 2-digit Subtraction Algorithm Tests
Second Grade Class

Class	Administration date				
	1/24	2/16	3/6	3/23	4/21
XF	1.0	1.1	0.8	1.6	1.4
CF	0.6	0.7	1.1	1.1	1.0
XR	0.3	0.4	0.8	0.9	1.0
CR	0.7	0.9	0.9	1.0	1.0

Note. XF - Experimental class, Falk School
CF - Control class, Falk School
XR - Experimental class, Orchard Ridge School
CR - Control class, Orchard Ridge School

children perform at a noticeably lower level on the subtraction algorithm than they do on addition. It was a bit surprising that the Falk classes did only as well as the Orchard Ridge classes because, as noted above, the Falk classes received some instruction in use of the algorithm while the Orchard Ridge classes received none.

Place value of 2-digit numbers. Table 4-6 presents data on the four separate administrations of a 12-item test. There is no clearly identifiable reason that accounts for the extreme fluctuation of results from the Orchard Ridge classes.

Ordering of 2-digit numbers. Table 4-7 presents data on the four separate administrations of a 6-item test. Despite an occasional fluctuation, these data appear to conform to the more normal pattern of gradual and expected growth over the testing period.

Basic multiplication facts. Very little, if any, multiplication is taught in second grade. When taught, it comes near the end of the school year. Thus, this test was only administered twice. Table 4-8 presents the data for the two 6-item tests. Given only two administrations, the data are insufficient to make any meaningful analysis. We now turn to the results from the third-grade classes.

Basic addition/subtraction facts. As one might expect, the third grade children demonstrated quickly that they had a high mastery level of the basic facts. Therefore, only three administrations were necessary. Table 4-9 presents the combined data for addition and subtraction.

Table 4-6

Mean Scores on 12-item Place Value Test
Second Grade Class

Class	Administration date			
	2/16	3/6	3/23	4/21
XF	8.3	9.2	7.7	7.6
CF	8.9	9.8	8.8	8.7
XR	6.9	8.3	8.0	5.4
CR	5.8	7.7	4.7	6.1

Note. XF - Experimental class, Falk School
CF - Control class, Falk School
XR - Experimental class, Orchard Ridge School
CR - Control class, Orchard Ridge School

Table 4-7

Mean Scores on Six-item Ordering Numbers Test
Second Grade Class

Class	Administration date			
	2/16	3/6	3/23	4/21
XF	5.4	5.1	4.6	5.6
CF	4.7	5.3	5.9	5.7
XR	4.9	5.5	5.7	5.9
CR	3.2	2.4	2.8	4.2

Note. XF - Experimental class, Falk School
CF - Control class, Falk School
XR - Experimental class, Orchard Ridge School
CR - Control class, Orchard Ridge School

Table 4-8

Mean Scores on Six-item Basic Multiplication Facts Test
Second Grade Class

Class	Administration date 3/23	4/21
XF	2.0	2.6
CF	1.9	1.6
XR	2.5	1.3
CR	2.4	2.2

Note. XF - Experimental class, Falk School
CF - Control class, Falk School
XR - Experimental class, Orchard Ridge School
CR - Control class, Orchard Ridge School

Table 4-9

Mean Scores on Six-item Addition/Subtraction Basic Facts Test
Third Grade Class

Class	Administration date 10/21	11/10	11/30
XF	6.0 (6.0)	5.9 (6.0)	6.0 (6.0)
CF	5.9 (5.7)	6.0 (5.6)	5.9 (5.7)
XR	6.0 (5.7)	5.9 (5.5)	6.0 (5.8)
CR	5.3 (5.6)	5.9 (5.9)	5.7 (5.7)

Note. XF - Experimental class, Falk School
CF - Control class, Falk School
XR - Experimental class, Orchard Ridge School
CR - Control class, Orchard Ridge School

The data resemble those of second grade in that, with one exception, performance on addition is slightly better than or equal to subtraction.

Solving open addition and subtraction sentences. The numbers in these sentences were 1-digit. Thus, performance seemed to be closely related to the students' mastery levels on the basic facts. After three administrations, performance indicated that students were at very high levels and were close to "topping out." Table 4-10 presents the data for the three administrations. The slight dip indicated in the second administration is attributable to slightly more difficult number combinations that occurred in the random selection of problems.

The addition algorithm. During the experiment, third-grade children were tested on addition of two 2-digit, 3-digit, and 4-digit numbers. They were tested with two items on each administration except that for the first three administrations of the 3-digit algorithm only one item was used. Testing of the 2-digit and 3-digit algorithms ended sooner for the Falk School classes than the Orchard Ridge classes because of the differences in curriculum emphases at the two schools. Table 4-11 presents the data for the various administrations.

The data suggest strong overall performance on the addition algorithm. Particular notice is given to the performance with 4-digit numbers since little or no formal instruction was provided on these problems. The relative ease of transfer of skill is strongly suggested.

The subtraction algorithm. Similar to addition, tests of 2-digit, 3-digit, and 4-digit subtraction were given over the year. All four classes received all administrations. Table 4-12 presents the data.

Table 4-10

Mean Scores on Six-item Solving Open Addition and Subtraction Sentences
Third Grade Class

Class	Administration Date		
	10/21	11/10	11/30
XF	5.2	4.6	5.2
CF	5.2	4.9	5.3
XR	5.1	4.7	5.5
CR	4.8	4.5	5.3

Note. XF - Experimental class, Falk School
CF - Control class, Falk School
XR - Experimental class, Orchard Ridge School
CR - Control class, Orchard Ridge School

Table 4-11

Mean Scores on Two-item Addition Algorithm Tests
Third Grade Class

Class	Administration date								
	10/21	11/10	11/30	12/20	1/24	2/16	3/6	3/23	4/21
	2-digit (3-digit) numbers					4-digit numbers			
	--[a]	--[a]	--[a]						
XF	1.8(0.7)	2.0(1.0)	1.8(1.0)			1.6	1.8	1.7	1.6
CF	1.9(0.7)	1.9(0.9)	1.9(1.0)			1.6	1.4	1.4	1.3
XR	1.9(0.9)	1.9(0.9)	1.9(1.0)	NA[b]	1.8(2.0)	1.9	2.0	1.6	1.6
CR	1.8(0.5)	1.5(0.6)	1.5(1.0)	1.7(1.4)	1.6(1.8)	1.5	1.6	1.5	1.8

[a]Test for 3-digit addition consisted of only one item on these days.

[b]NA - test inadvertently not administered to this class on this day.

Note. XF - Experimental class, Falk School
CF - Control class, Falk School
XR - Experimental class, Orchard Ridge School
CR - Control class, Orchard Ridge School

Table 4-12

Mean Scores on Two-item Subtraction Algorithm Tests
Third Grade Class

Class	Administration date								
	10/21	11/10	11/30	12/20	1/24	2/16	3/6	3/23	4/21
	2-digit (3-digit) numbers					4-digit numbers			
	--a	--a	--a	--b	--b				
XF	1.7(1.0)	1.6(0.5)	1.6(0.5)	(3.3)	(4.7)	1.1	1.4	1.2	1.1
CF	1.4(1.0)	1.5(0.5)	1.5(0.5)	(3.1)	(3.7)	1.2	1.5	1.0	0.8
XR	1.5(0.8)	1.5(0.4)	1.8(0.6)	NA[c]	(5.1)	1.4	1.8	1.7	1.3
CR	1.5(0.9)	1.7(0.4)	1.5(0.5)	(3.9)	(4.3)	1.0	1.4	0.9	1.0

[a]Test for 3-digit subtraction consisted of only one item on this day.

[b]Test for 3-digit subtraction consisted of six items on this day.

[c]NA - test inadvertently not administered to this class on this day.

Note. XF - Experimental class, Falk School
CF - Control class, Falk School
XR - Experimental class, Orchard Ridge School
CR - Control class, Orchard Ridge School

The upward and downward variation from one administration to another is a function of the number of items requiring regrouping. For example, on the 10/21 administration of the single 3-digit problem, the mean perfect performance is because no regrouping was required. In contrast, the subsequent testing of 3-digit subtraction on 11/10 produced much poorer performance because regrouping was required.

Multiplication basic facts. This area of skill development receives a great deal of attention in third grade. Consequently, it was examined throughout the entire duration of the study with the exception of the last administration in which it was given to the Orchard Ridge classes only. Table 4-13 presents the data for the nine administrations.

The data present the overall picture of growth, which is as one would expect. It should be remembered that all children in the Falk classes took each test, while at Orchard Ridge only half the children took the tests. This could account in part for the more stable pattern of growth present in the Falk data than in the Orchard Ridge data.

Division basic facts. The language and conventional notation for division does not appear at all in the third grade mathematics program used at Orchard Ridge. Consequently, the decision was made not to test those children in this area. The data for the four administrations with the Falk children are presented in Table 4-14. The basic division facts were given on the test in two forms, $a\overline{)b}$ and $b \div a$. The children were equally adept with either notational form. The performance level is not

Table 4-13

Mean Scores on Six-item Basic Multiplication Facts Test
Third Grade Class

Class	Administration date								
	10/21	11/10	11/30	12/20	1/24	2/16	3/6	3/23	4/21
XF	2.8	1.9	2.8	2.9	4.6	5.1	5.3	5.5	
CF	4.3	3.9	4.9	4.3	5.0	4.6	4.7	5.0	
XR	3.5	2.0	3.6	NA[a]	4.2	3.4	3.7	5.5	4.5
CR	3.2	2.0	2.1	4.0	4.6	3.3	4.4	4.4	5.3

[a]NA--Test inadventently not administered to this class on this day.

Note. XF - Experimental class, Falk School
CF - Control class, Falk School
XR - Experimental class, Orchard Ridge School
CR - Control class, Orchard Ridge School

Table 4-14

Mean Scores on Five-item Basic Division Facts Test
Third Grade Class

Class	Administration date			
	2/16	3/6	3/23	4/21
XF	3.1 (3.3)	3.9 (3.9)	4.0 (4.2)	3.5 (3.4)
CF	2.9 (2.9)	3.4 (3.3)	3.6 (3.5)	3.5 (3.4)

$a\sqrt{b}$ notation (b ÷ a notation)

Note. XF - Experimental class, Falk School
CF - Control class, Falk School

as high as it is for basic multiplication facts. This simply reflects instruction, and one must keep in mind that basic division facts are not introduced until much later in the academic year.

Solving open multiplication sentences. These open sentences are of the form $a \times b = p$ where either a or b is missing. They are a way of assessing knowledge or understanding of the relationship between multiplication and division. Data on the six administrations of the 6-item test are given in Table 4-15. Except for the XR class, the general trend of the data suggest a pattern of growth over the testing period.

Multiplication of a 2-digit number by a 1-digit number. This particular skill is one that receives attention in the latter portion of a conventional mathematics program. As such it was an appropriate test for the Falk School students but not for those in Orchard Ridge School. Data on the four administrations of an 8-item test given in the second half of the experimental period are presented in Table 4-16.

The unexpected drop in performance on the last test, particularly in the XF class is unexplainable. Test items were not unusually difficult in terms of their related basic fact components. We can only conjecture that some unreported occurrence within the school interfered with the children's normal testing routine.

Place value of smaller and larger numbers. This testing can be divided into two parts. The first is concerned with relatively small 2- and 3-digit numbers and the latter with larger, multidigit numbers. Because of curricular differences, most of the testing with larger numbers took

Table 4-15

Mean Scores on Six-item Solving Open Multiplication Sentences Test
Third Grade Class

Class	Administration date					
	12/20	1/24	2/16	3/6	3/23	4/21
XF	1.6	4.0	3.9	5.1	5.3	5.1
CF	3.4	3.8	3.9	4.5	4.8	4.3
XR	NA[a]	2.2	3.2	2.1	4.8	2.7
CR	2.5	2.8	2.4	2.5	3.3	3.6

[a]NA - Test inadvertently not administered to this class on this day.

Note. XF - Experimental class, Falk School
CF - Control class, Falk School
SR - Experimental class, Orchard Ridge School
CR - Control class, Orchard Ridge School

Table 4-16

Mean Scores on Eight-item Test on Multiplication
of a 2-digit Number by a 1-digit Number
Third Grade Class

Class	Administration date			
	2/16	3/6	3/23	4/21
XF	4.0	5.7	5.8	4.1
CF	4.8	4.7	4.8	4.5

Note. XF - Experimental class, Falk School
CF - Control class, Falk School

place in Orchard Ridge School. The data are presented in Table 4-17. The data indicate that varied instructional emphases exist within the same school.

Summary

The short tests were instituted as part of the data collection process to determine any drastic or unexpected changes in the performance levels of participating students. Another purpose was to inform the participating teachers on a regular basis that no harmful effects from using calculators were taking place. The short nature of the tests and the resulting small numbers of items testing a specific skill prohibit our making any statistical comparisons. This was not the intent of the short tests; the major tests reported in Chapter Three served that purpose.

Although random fluctuations in performance levels from one administration to the next did occur, the overall picture is one of growth from beginning to end. Of course, that was not unexpected. Perhaps the safest conclusion that may be drawn from the data presented in this chapter is that the children did, indeed, learn what they were taught.

Table 4-17

Mean Scores on Six-item Tests (Smaller Numbers) and Twelve-item (Larger Numbers) on Place Value Third Grade Class

Class	Administration date						
	10/21	11/10	11/30	2/16	3/6	3/23	4/21
	Smaller numbers			Larger numbers			
XF	4.5	5.0	5.1				9.4
CF	4.6	5.1	5.2				6.7
XR	5.3	4.2	5.2	9.9	9.6	10.5	10.1
CR	3.1	4.2	4.2	5.4	5.9	6.5	7.6

Note. XF - Experimental class, Falk School
CF - Control class, Falk School
XR - Experimental class, Orchard Ridge School
CR - Control class, Orchard Ridge School

Chapter Five

Discussion of Results

Limitations

While similar procedures and testing instruments were used, it must be recognized that the present study was in reality two studies, one of second graders and the other of third graders. The vast difference in performance on addition/subtraction basic facts on the fall pretest, for example, indicates that the two grade levels were operating on entirely different background and achievement levels and therefore any comparison between grades would be meaningless.

Because of the small number of classes in each treatment at each grade level, the experimental design did little to control for possible teacher effects. Consequently, the decisions about statistical significance of differences between mean change scores on the various subtests administered rested upon the rule that the difference, if any, had to be present for both classes. In general, the overall effect for combined classes had to be significant at the .05 level of probability. However, each of the individual classes did not have to have a difference at that significance level. Ordinarily, if a significant difference existed for the combined classes, then at least one of the classes also had a difference at that significance level while the other was either also statistically significant or close to the required probability level.

The small number of classes involved in the study also limits the generalizability of the study. Another factor to be considered is the location of the schools involved in the study. Both schools serve an upper middle class area composed mainly of professional persons, many of whom are connected with a major university. On the other hand, the fact that many of the children had access to a calculator in their homes should not be considered as atypical. Other studies have shown a very widespread presence of calculators in homes that cut across almost all socioeconomic strata with the possible exception of native Americans.

Cognitive Results

Requiring a test of significance to have a prestated probability value is certainly justified on logical grounds. However, ignoring those differences that are not quite at the desired level may mask some potential findings or trends, particularly when a number of measures are used as was the case in the present study. Therefore, the decision was made to tabulate the results of the various subtests given to see if any possible trend emerged that would indicate a potential effect of the experimental treatment. In the tabulation, only differences whose associated F statistic had a p value less than .25 were listed with those having the p value less than .05 being noted as statistically significant.

The results for the second-grade classes are given in Table 5-1. The following subtest comparisons are not included since their p values exceeded the prescribed limit of .25: Basic addition facts S-F,

Table 5-1

Second Grade Results

Subtest	Combined		Falk School		Orchard Ridge School	
	$p<.05$	$.05<p<.25$	$p<.05$	$.05<p<.25$	$p<.05$	$.05<p<.25$
Basic subtraction facts S-F	X		X			X
Basic addition facts W-F		C			C	
Basic addition facts S-W				C	X	
Basic subtraction facts S-W	X		X			X
Solve open sentence S-F	X				X	
Solve open sentence S-W		X		C	X[a]	
2-digit subtraction S-F	X[a]		X		X[a]	
2-digit addition W-F			X		C	
2-digit subtraction W-F		X				
2-digit addition S-W				C	X	
2-digit subtraction S-W	X			X	X	
3-digit addition S-W	X				X[a]	
3-digit subtraction S-W	X[a]		X		X[a]	
Ordering 2-digit numbers S-W	C[a]		C		C	
Total X	7	2	5	1	8	2
Total C	1	1	1	3	3	0

[a] $p < .001$

X - difference in favor of experimental class
C - difference in favor of control class

Basic subtraction facts W - F, Solving open sentences W - F, 2-digit addition S - F, Place value of 2-digit numbers S - W, and Basic multiplication facts S - W.

It is recognized that some of these comparisons are dependent upon others. For example, a highly significant difference at one school would surely have an effect on the amount of difference of the combined classes. Also, to a certain degree, the W - F and S - W differences are components of the longer range comparison S - F. Nevertheless, the data in Table 5-1 strongly suggest that if the experimental treatment had any effect at all, it was a positive one. On the other hand, it is reasonable to conclude that the use of calculators in the two second grade classes had no harmful effect upon the students in those classes.

It is interesting to speculate upon the reasons for the consistent pattern of significant differences in favor of the experimental classes on all three major subtests dealing with subtraction. The consistency across all three tests indicates a strong effect present in the two classrooms. There were no notable initial differences between either of the two classes on any of the pretests. Teacher logs of daily activities do not indicate that any strong emphasis was given to subtraction in the experimental classes. Yet there is nothing especially unique about the hand-held calculator that would suggest that it would produce a strong effect on subtraction as opposed to addition or multiplication. While it might be tempting to assume that the use of calculators explained the large differences, the fact that similar differences did not occur for addition or for any of the other skills measured on the various subtests leads one to a more conservative conclusion--teacher effect was the primary

source. The probability of the chance occurrence that both experimental teachers independently chose to stress subtraction more than their control class counterparts is not that small.

The other major difference to be noted is in the subtest covering ordering of 2-digit numbers. The hypotheses as to why the control class performed at a significantly higher level were advanced in Chapter 3.

The various tests of significance for the third grade subtests were also tabulated according to the rules set forth earlier in this chapter. It was decided not to consider any differences as being important if overall gains (or losses) were extremely small due to no real growth taking place or because the ceiling effect was present. This latter case tended to be true for basic addition and subtraction facts. Results of this analysis are presented in Table 5-2.

Several factors deserve special comment. Subtraction performance again appears to favor the experimental groups. When this is compared to very similar results with the second graders, one begins to wonder whether there is some interactive effect between calculators and the operation of subtraction. Performance on the place value subtests strongly favor the experimental groups at a very high level of significance. Here, the characteristics of the calculator come into consideration. When a child enters a multi-digit number on the calculator, he or she must be acutely aware of place value and the positional value of the digits in order to enter the number correctly. Successive entries of digits move the

Table 5-2

Third Grade Results

Subtest	Combined		Falk School		Orchard Ridge School	
	$p<.05$	$.05<p<.25$	$p<.05$	$.05<p<.25$	$p<.05$	$.05<p<.25$
2-digit addition S-F		X				
2-digit addition W-F						C
2-digit subtraction S-F		X	X			
2-digit subtraction S-W					X	
2-digit subtraction W-F			X		C	
3-digit addition S-F		X		X		
3-digit subtraction S-F	X		X			X
3-digit addition W-F						C
3-digit subtraction W-F						C
3-digit subtraction S-W	X				X	
4-digit addition/subtraction S-W		X		X		
Place value S-F	X[a]		X[a]			X
Place value S-W	X		X[a]			
Ordering S-F				X		
Ordering S-W				X		
Basic multiplication S-F			X		C	
Basic multiplication S-W	X		X			
Basic division S-F	X		X			X
Basic division S-W	X		X			X
Multiplication 2 x 1 S-W			X			
Total X	7	4	10	4	2	4
Total C	0	0	0	0	2	3

[a] p .001

X - difference in favor of experimental class.
C - difference in favor of control class.

first-entered digit from the 1's place to the 10's place to the 100's place, and so on. Therefore, it is reasonable to conjecture that children who used a calculator more consistently than those who had no classroom access to a calculator might perform better on a measure of place value because of that increased use.

The third notable result in the third-grade classes involves division facts. Here again, the presence of calculators may have made a real difference. The division symbol was present on the calculators used by the children in the experimental classes. Therefore, they probably were made more aware of the symbol and what it meant than children without calculators. It must be remembered that the division symbol is not ordinarily introduced in a canonical curriculum, such as that at Falk School, until the latter part of the third grade. In the DMP curriculum used at Orchard Ridge School, it is not introduced at all in third grade. As the results in Table 5-2 indicate, the experimental classes performed at a significantly higher level on tests measuring knowledge of basic division facts than the control classes.

Finally, the overall pattern of performance as indicated by Table 5-2 shows more positive differences in favor of the experimental classes. This pattern is similar to the one exhibited by the second grade. In a similar fashion, it is not safe to conclude that the positive effects were due to the use of calculators in those classes. Yet, it is reasonable to state that no harmful effects can be attributed to the use of calculators in the third grade classes participating in this study. These overall conclusions are consistent with those reported by Shumway (Note 1).

Affective Results

Many of the studies reported in Chapter 1 investigated the effects of calculators upon student activities. Sufficient research had been done in this regard so that it was unnecessary to obtain any formal measures. However, some indication of pupil and teacher reaction to calculator use was obtained through classroom visitations and informal conversations with the participating teachers. During the initial stages of introduction to and use of the calculators, a high degree of interest and enthusiasm was shown by the children. As the year wore on and as the children became more familiar with the calculators, their enthusiasm waned somewhat. This was particularly true when children had to use the calculator to check a long series of computational exercises. Teachers did state that the children enjoyed using the calculators to play the several games that were introduced.

The teachers themselves reported that they believed the use of calculators generally was beneficial to the children. Part of this was due to their involvement in the experiment--using something different made mathematics lessons more interesting. An overall higher degree of interest in doing mathematics seemed to pervade the experimental groups. The teachers also reported that using the calculators did not present an undue burden on their ability to manage classroom activities while the machines were being used.

Implications for Further Investigation

The major finding of the study described in this report is that use of calculators as a supplementary device to the regular ongoing curriculum in selected second and third grade classrooms in no way proved detrimental to children's performance on standard arithmetic tasks. When this finding is complemented by the results of a large, National Science Foundation funded study (see Shumway, Note 1) that were similar, one is essentially led to the conclusion that using calculators as supplementary devices in elementary classrooms need not be feared by educators as something that might "rot the mind" of young children. The fact that this study produced overall results that appeared to be strongly in favor of the experimental classes indicates that there well may be some potential benefit to using calculators as an integral part of the elementary curriculum in mathematics.

Therefore, it is strongly recommended that further study be initiated to investigate the effects of calculators at all levels of instruction--ideally in situations where the calculator is more carefully and systematically integrated into the curriculum. This means that curriculum development is necessary. Conceptualization of instructional materials should be followed by development and tryout of materials in carefully controlled teaching experiments. Writers and teachers should seek ways to use the distinctive features of electronic devices--whether they be calculators or microprocessors--to best advantage to promote deeper conceptual understanding of mathematics and higher levels of computational and problem solving ability.

Some work is being done in this area, but it tends to be at upper grade levels. Investigators should be willing to work with younger children in the primary grades. The children involved in this study demonstrated convincingly that they are quickly able to learn how to operate calculators and tc use them to derive simple computational solutions. Results may show that the time necessary to lead children to the desired levels of understanding and skills may be too great so that other, more important, mathematical outcomes are not being met. It should not be inferred from the above recommendations that ultimately we must demonstrate that calculators are superior to former methods of instruction. All that is being called for is scholarly investigation into the question of how, when and if calculators can be effectively used to lead young children to greater levels of mathematical literacy.

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APPENDIX A

Copies of Tests

Tests were essentially identical except for slight notational differences on some subtests. Only one version of each test is presented in this appendix.

Fall Pretest

Second Grade

114

Instructions for Test Administration of Second Grade Pretest

To the teacher: These are simply suggestions for directions for you. Feel free to paraphrase or use your own words that convey the same meaning.

Distribute the test booklets. Say: Do not turn the page until I tell you to do so. Print your first name and last name on the line.

After the children have written their names, say: On these pages you will be asked to work some math problems. You may find some problems that you cannot do. Don't feel bad about that. The reason you are trying these problems is to help me find out what you do know and what you do not know. All that I ask is that you do the best you can and that you do your own work. Please don't look on any one else's paper.

NOW OPEN TO THE NEXT PAGE.

These are addition and subtraction facts. Half of the page is about addition and half is about subtraction. I am going to let you work on this page for only three minutes. Work quickly but don't be careless. If you come to a problem you don't know the answer for, don't waste too much time trying to figure it out. Go on to the next one. All right, begin.

At the end of 1 1/2 minutes, say: If you have not yet started on the subtraction problems, you should start on them now.

At the end of the next 1 1/2 minutes, say: Put your pencils down.

TURN TO THE NEXT PAGE

Look at the directions. The directions say, Solve the Number Sentences. That means that you should figure out what to write in the box to make a true sentence. Use whatever method you want to help you find the right answer. You will have only a limited time to do these so do not waste too much time on a problem you nay not be able to do. All right, begin.

At the end of 7 minutes, say: Put your pencils down.

TURN TO THE LAST PAGE

These problems ask you to add or subtract bigger numbers. Most of you have probably not seen problems like this before. Remember I don't expect you to know how to do them. Just see if you can find a way to get the answers. Don't feel bad or disappointed if you can't do them. All right, begin.

At the end of 3 minutes, say: Put your pencils down.

Collect the papers.

Add

2 + 5	6 +0	1 +7	4 +4	3 +2	0 +9
5 +4	6 +1	5 +0	2 +7	4 +6	8 + 5	1 +9
7 + 4	3 + 8	8 + 6	5 +5	8 + 4	9 + 3	6 + 8

Subtract

8 - 4	9 -3	6 -2	8 -1	9 - 7	9 -0
5 -4	4 -4	6 -0	5 -2	14 - 5	16 - 7	11 - 4
15 - 6	12 - 4	10 - 6	17 - 9	14 - 7	13 - 8	17 - 8

Solve the number sentences.

$9 + 2 = \square$	$5 - 1 = \square$	$\square = 3 + 6$
$\square = 14 - 8$	$3 + \square = 7$	$\square + 2 = 4$
$10 = 9 + \square$	$12 = \square + 7$	$\square = 8 - 3$
$\square = 7 + 4$	$16 - 9 = \square$	$4 + 0 = \square$
$1 = \square + 1$	$6 = 5 + \square$	$\square + 9 = 11$
$5 + \square = 13$	$\square - 3 = 4$	$8 - \square = 7$
$5 = 14 - \square$	$1 = \square - 5$	$4 = \square - 8$
$0 = 9 - \square$	$\square - 4 = 6$	$10 - \square = 3$

Add

$$\begin{array}{r} 43 \\ +25 \\ \hline \end{array}$$

$$\begin{array}{r} 27 \\ +62 \\ \hline \end{array}$$

$$\begin{array}{r} 38 \\ +45 \\ \hline \end{array}$$

$$\begin{array}{r} 19 \\ +44 \\ \hline \end{array}$$

Subtract

$$\begin{array}{r} 87 \\ -51 \\ \hline \end{array}$$

$$\begin{array}{r} 94 \\ -60 \\ \hline \end{array}$$

$$\begin{array}{r} 70 \\ -39 \\ \hline \end{array}$$

$$\begin{array}{r} 31 \\ -15 \\ \hline \end{array}$$

Midyear Test

Second Grade

Instructions for Test Administration of Second Grade Midyear Test--Part I (Day 1)

To the teacher: These are simply suggestions for directions for you. Feel free to paraphrase or use your own words that convey the same meaning. But, observe the time limits carefully.

Distribute the test booklets. Say: Do not turn the page until I tell you to do so. Print your first name and last name on the line.

After the children have written their names, say: On these pages you will be asked to work some math problems. You may find some problems that you cannot do. Don't feel bad about that. The reason you are trying these problems is to help me find out what you do know and what you do not know. All that I ask is that you do the best you can and that you do your own work. Please don't look on any one else's paper.

NOW OPEN TO THE NEXT PAGE.

These are addition and subtraction facts. Half of the page is about addition and half is about subtraction. I am going to let you work on this page for only three minutes. Work quickly but don't be careless. If you come to a problem you don't know the answer for, don't waste too much time trying to figure it out. Go on to the next one. All right, begin.

At the end of 1 1/2 minutes, say: If you have not yet started on the subtraction problems, you should start on them now.

At the end of the next 1 1/2 minutes, say: Put your pencils down.

TURN TO THE NEXT PAGE

Look at the directions. The directions say,"Solve the Number Sentences." That means that you should figure out what to write in the box to make a true sentence. Use whatever method you want to help you find the right answer. You will have seven minutes to do these so do not waste too much time on a problem you may not be able to do. All right, begin.

At the end of 7 minutes, say: Put your pencils down.

TURN TO THE LAST PAGE

These problems ask you to add or subtract bigger numbers. You will have three minutes to do these problems so don't waste too much time on one problem.

At the end of 3 minutes, say: Put your pencils down.

Collect the papers.

Instructions for Test Administration of Second Grade Midyear Test--Part II (Day 2)

To the teacher: These are simply suggestions for directions for you. Feel free to paraphrase or use your own words that convey the same meaning. Please observe the time limits carefully.

Distribute the test booklets. Say: Do not turn the page until I tell you to do so. Print your first name and last name on the line.

After the children have written their names, say: On these pages you will be asked to work some math problems. You may find some problems that you cannot do. Don't feel bad about that. The reason you are trying these problems is to help me find out what you do know and what you do not know. All that I ask is that you do the best you can and that you do your own work. Please don't look on any one else's paper.

NOW OPEN TO THE NEXT PAGE

These are addition and subtraction problems. Half of the page is about addition and half is about subtraction. I am going to let you work on the page for only four minutes. Work quickly but don't be careless. If you come to a problem you don't know the answer for, don't waste too much time trying to figure it out. Go on to the next one. All right, begin.

At the end of 2 minutes, say: If you have not yet started on the subtraction problems, you should start on them now.

At the end of the next 2 minutes, say: Put your pencils down.

TURN TO THE NEXT PAGE

Before you begin this page, let's make sure we all can read the directions. At the top, it says, "Write the Missing Numbers." This means you should write the missing number in the box. In the middle of the page, it again says, "Write the Missing Numbers." This means you should write the missing numbers on the little lines. You will only have four minutes to do this page. So work quickly and don't waste time. If you come to one you cannot do, don't spend too much time trying to figure it out but go on to the next problem. All right, begin.

At the end of 4 minutes, say: Put your pencils down.

TURN TO THE LAST PAGE

The directions at the top say,"Write the Product." That means to give the answer when you multiply two numbers together. For example, the first problem says 6 times 5. The letter x means to multiply, not to add. I know that many of you may not have seen these kinds of problems before. That is all right. If you don't know how to do them, don't feel badly. You are not really expected to know how to do them. I just want to find out if any of you do know how to work problems of this type. The sentences at the bottom of the page are also about multiplying. Just remember to do the best you can on this page. You will have three minutes to work on this page. All right, begin.

At the end of 3 minutes, say: Put your pencils down.

Collect the papers.

ADD

3 + 3	4 + 5	3 + 4	1 + 4	6 + 3	8 + 0
5 + 2	5 + 3	7 + 2	2 + 4	9 + 7	7 + 4	8 + 7
3 + 8	7 + 6	9 + 1	9 + 5	3 + 9	6 + 8	5 + 6

SUBTRACT

8 - 3	7 - 0	7 - 4	9 - 5	9 - 9	6 - 4
4 - 1	7 - 5	5 - 2	8 - 2	11 - 9	16 - 9	14 - 5
18 - 9	14 - 6	13 - 7	12 - 3	16 - 7	17 - 8	11 - 7

SOLVE THE NUMBER SENTENCES.

9 + 3 = ☐	6 - 3 = ☐	☐ = 6 + 3
☐ = 16 - 8	3 + ☐ = 5	☐ + 3 = 7
13 = 5 + ☐	12 = ☐ + 6	☐ = 8 - 0
☐ = 8 + 9	15 - 7 = ☐	5 + 3 = ☐
6 = ☐ + 6	6 = 2 + ☐	☐ + 6 = 15
5 + ☐ = 11	☐ - 2 = 6	4 - ☐ = 1
4 = 13 - ☐	4 = ☐ - 5	6 = ☐ - 4
7 = 9 - ☐	☐ - 9 = 5	11 - ☐ = 7

ADD

$$\begin{array}{r} 51 \\ +\ 27 \\ \hline \end{array} \qquad \begin{array}{r} 30 \\ +21 \\ \hline \end{array}$$

$$\begin{array}{r} 29 \\ +32 \\ \hline \end{array} \qquad \begin{array}{r} 45 \\ +\ 28 \\ \hline \end{array}$$

SUBTRACT

$$\begin{array}{r} 88 \\ -76 \\ \hline \end{array} \qquad \begin{array}{r} 56 \\ -25 \\ \hline \end{array}$$

$$\begin{array}{r} 72 \\ -28 \\ \hline \end{array} \qquad \begin{array}{r} 83 \\ -67 \\ \hline \end{array}$$

ADD

265	503	174	426
+ 314	+ 293	+ 642	+ 458

SUBTRACT

482	698	846	256
- 231	- 457	- 393	- 138

WRITE THE MISSING NUMBERS.

$3(10) + 4 = \square$

$5(10) + 0 = \square$

$6(10) + 18 = \square$

$\square (10) + 1 = 81$

$2(10) + \square = 25$

$4(10) + \square = 56$

$70 + 7 = \square$

$40 + 6 = \square$

$30 + 19 = \square$

$\square + 2 = 52$

$90 + 3 = \square$

$\square + 14 = 74$

WRITE THE MISSING NUMBERS.

77, ___, 79

40, 41, ___, 43

27, 28, ___, ___

___, 53, 54

___, 39, 40

___, ___, 21

SOLVE THE NUMBER SENTENCES.

6(5) = ☐	0(3) = ☐	7(7) = ☐
4(7) = ☐	5(3) = ☐	6(1) = ☐
3(9) = ☐	6(8) = ☐	9(2) = ☐
4(9) = ☐	5(4) = ☐	7(8) = ☐

Spring Posttest

Second Grade

Instructions for Test Administration of Second Grade End-of-Year Test--Part I
(Day 1)

To the teacher: These are simply suggestions for directions for you. Feel free to paraphrase or use your own words that convey the same meaning. But, observe the time limits carefully.

Distribute the test booklets. Say: Do not turn the page until I tell you to do so. Print your first name and last name on the line.

After the children have written their names, say: On these pages you will be asked to work some math problems. You may find some problems that you cannot do. Don't feel bad about that. The reason you are trying these problems is to help me find out what you do know and what you do not know. All that I ask is that you do the best you can and that you do your own work. Please don't look on any one else's paper.

NOW OPEN TO THE NEXT PAGE.

These are addition and subtraction facts. Half of the page is about addition and half is about subtraction. I am going to let you work on this page for only three minutes. Work quickly but don't be careless. If you come to a problem you don't know the answer for, don't waste too much time trying to figure it out. Go on to the next one. All right, begin.

At the end of 1 1/2 minutes, say: If you have not yet started on the subtraction problems, you should start on them now.

At the end of the next 1 1/2 minutes, say: Put your pencils down.

TURN TO THE NEXT PAGE

Look at the directions. The directions say,"Solve the Number Sentences." That means that you should figure out what to write in the box to make a true sentence. Use whatever method you want to help you find the right answer. You will have seven minutes to do these so do not waste too much time on a problem you may not be able to do. All right, begin.

At the end of 7 minutes, say: Put your pencils down.

TURN TO THE LAST PAGE

These problems ask you to add or subtract bigger numbers. You will have three minutes to do these problems so don't waste too much time on one problem.

At the end of 3 minutes, say: Put your pencils down.

Collect the papers.

Instructions for Test Administration of Second Grade End-of-Year Test Part II (Day 2)

To the teacher: These are simply suggestions for directions for you. Feel free to paraphrase or use your own words that convey the same meaning. Please observe the time limits carefully.

Distribute the test booklets. Say: Do not turn the page until I tell you to do so. Print your first name and last name on the line.

After the children have written their names, say: On these pages you will be asked to work some math problems. You may find some problems that you cannot do. Don't feel bad about that. The reason you are trying these problems is to help me find out what you do know and what you do not know. All that I ask is that you do the best you can and that you do your own work. Please don't look on any one else's paper.

NOW OPEN TO THE NEXT PAGE

These are addition and subtraction problems. Half of the page is about addition and half is about subtraction. I am going to let you work on the page for only four minutes. Work quickly but don't be careless. If you come to a problem you don't know the answer for, don't waste too much time trying to figure it out. Go on to the next one. All right, begin.

At the end of 2 minutes, say: If you have not yet started on the subtraction problems, you should start on them now.

At the end of the next 2 minutes, say: Put your pencils down.

TURN TO THE NEXT PAGE

Before you begin this page, let's make sure we all can read the directions. At the top, it says, "Write the Missing Numbers." This means you should write the missing number in the box. In the middle of the page, it again says, "Write the Missing Numbers." This means you should write the missing numbers on the little lines. You will only have four minutes to do this page. So work quickly and don't waste time. If you come to one you cannot do, don't spend too much time trying to figure it out but go on to the next problem. All right, begin.

At the end of 4 minutes, say, Put your pencils down.

TURN TO THE LAST PAGE

The directions at the top say, "Solve the Number Sentences." If you look at the sentences, you can see that they are about grouping. I want you to write the number in the box that makes the sentence true. Use what you know about grouping to help you. These sentences are new to you and many may not be able to solve all the sentences. Don't feel badly if you cannot do these. Remember I am trying to find out what things you can do and wh[illegible] things y[illegible]u cannot do. Just do the best you can, but at least try them. You will have three minutes to work on this page. All right, begin.

At the end of 3 minutes, say: Put your pencils down.

Collect the papers.

ADD

5 + 4	4 + 2	8 + 1	2 + 6	0 + 4	7 + 2
2 + 3	7 + 0	4 + 3	3 + 5	7 + 4	3 + 9	5 + 5
7 + 9	8 + 6	6 + 4	9 + 2	7 + 6	8 + 4	7 + 8

SUBTRACT

9 - 2	6 - 1	5 - 5	8 - 4	2 - 0	6 - 3
9 - 8	8 - 6	7 - 3	4 - 2	10 - 3	17 - 9	13 - 8
10 - 7	12 - 4	14 - 9	13 - 9	12 - 7	15 - 6	16 - 7

SOLVE THE NUMBER SENTENCES.

5 + 8 = ☐	2 = 9 - ☐	10 = ☐ + 2
☐ = 4 - 0	4 + ☐ = 13	☐ - 3 = 3
9 = 15 - ☐	☐ + 3 = 5	11 - 6 = ☐
7 + ☐ = 8	8 = ☐ - 5	☐ = 4 + 5
☐ + 8 = 16	4 - 2 = ☐	10 = 1 + ☐
3 = ☐ - 3	☐ = 6 + 8	8 - ☐ = 4
☐ = 16 - 7	8 = 3 + ☐	☐ - 7 = 6
4 + 3 = ☐	11 - ☐ = 7	9 = ☐ + 8

ADD

15 + 22	40 + 48
56 + 34	17 + 45

SUBTRACT

79 - 43	48 - 21
77 - 29	53 - 34

ADD

614	362	583	167
+ 384	+ 205	+ 241	+ 426

SUBTRACT

786	985	615	746
- 473	- 265	- 384	- 219

WRITE THE MISSING NUMBERS.

$5(10) + 3 = \square$ $\quad$ $9(10) + 0 = \square$

$2(10) + 14 = \square$ $\quad$ $\square + 3 = 73$

$8(10) + \square = 86$ $\quad$ $7(10) + \square = 82$

$60 + 6 = \square$ $\quad$ $10 + 8 = \square$

$40 + 16 = \square$ $\quad$ $\square + 7 = 47$

$80 + 9 = \square$ $\quad$ $\square + 13 = 23$

WRITE THE MISSING NUMBERS.

62, _____, 64 $\quad$ 20, _____, 22, 23

47, 48, _____, _____ $\quad$ _____, 75, 76

_____, 89, 90 $\quad$ _____, _____, 41

SOLVE THE NUMBER SENTENCES.

3(6) = ☐	9(4) = ☐	4(7) = ☐
5(5) = ☐	8(6) = ☐	4(8) = ☐
6(9) = ☐	3(7) = ☐	2(6) = ☐
7(8) = ☐	2(0) = ☐	1(9) = ☐

Fall Pretest

Third Grade

Instructions for Test Administration of Third Grade Pretest, Part I

To the teacher: These are simply suggestions for directions for you. Feel free to paraphrase or use your own words that convey the same meaning.

Distribute the test booklets. Say: Do not turn the page until I tell you to do so. Print your first name and last name on the line.

After the children have written their names, say: On these pages you will be asked to work some math problems. You may find some problems that you cannot do. Don't feel bad about that. The reason you are trying these problems is to help me find out what you do know and what you do not know. All that I ask is that you do the best you can and that you do your own work. Please don't look on any one else's paper.

NOW OPEN TO THE NEXT PAGE.

These are addition and subtraction facts. Half of the page is about addition and half is about subtraction. I am going to let you work on this page for only three minutes. Work quickly but don't be careless. If you come to a problem you don't know the answer for, don't waste too much time trying to figure it out. Go on to the next one. All right, begin.

At the end of 1 1/2 minutes, say: If you have not yet started on the subtraction problems, you should start on them now.

At the end of the next 1 1/2 minutes, say: Put your pencils down.

TURN TO THE NEXT PAGE

Look at the directions. The directions say, Solve the Number Sentences. That means that you should figure out what to write in the box to make a true sentence. Use whatever method you want to help you find the right answer. You will have only a limited time to do these so do not waste too much time on a problem you nay not be able to do. All right, begin.

At the end of 9 *minutes, say:* Put your pencils down.

TURN TO THE LAST PAGE

These problems ask you to add or subtract bigger numbers. Most of you have probably not seen problems like this before. Remember I don't expect you to know how to do them. Just see if you can find a way to get the answers. Don't feel bad or disappointed if you can't do them. All right, begin.

At the end of 3 *minutes, say:* Put your pencils down.

Collect the papers.

Instructions for Test Administration of Third Grade Pretest, Part II

To the teacher: These instructions are suggestions only. Feel free to paraphrase, modify, or amplify the directions to the children.

Distribute the test booklets. Say: Do not turn the page until I tell you to do so. Print your first name and last name on the line.

After the children have written their names, say: Today you are going to do more math problems. I am asking you to do these because I want to try to find out how much you know and what things you may not know. There may be some problems on these pages that you cannot do. Do not feel bad or disappointed. Just do the best you can and work on the ones you do know how to do. Remember, I want to know what you can do, not what someone else can do. So keep your eyes on your own paper.

NOW OPEN TO THE NEXT PAGE

The directions tell you to write the missing number. You should write that number in the box. You will only have three minutes to do this page. So work quickly and don't waste time. If you come to one you cannot do, don't spend too much time trying to figure it out but go on to the next problem. All right, begin.

At the end of three minutes, say: Put your pencils down.

TURN TO THE NEXT PAGE

Before you begin this page, let's make sure we all can read the directions. At the top, it says, "Write the missing numbers." This means you should write the missing numbers on the little lines. In the middle of the page, it says, "Write the numbers in order, smallest first." That means if the four numbers are not already written in order from smallest to largest, you have to re-write them on the little lines, putting the smallest number down first, then going in order so that the largest number is the last one you write. Down at the bottom, the directions are to circle the larger number in each pair--notice that there are four different pairs--and then

on the right hand side, put a large X on the smaller number in each pair--again, there are four different pairs. You will only have three minutes to work on this page. All right, begin.

At the end of three minutes, say: Put your pencils down.

TURN TO THE LAST PAGE

The directions at the top say, Write the Product. That means to give the answer when you multiply two numbers together. For example, the first problem says 2 times 3. The letter x means to multiply, not to add. I know that many of you may not have seen these kinds of problems before. That is all right. If you don't know how to do them, don't feel badly. You are not really expected to know how to do them. I just want to find out if any of you do know how to work problems of this type. The sentences at the bottom of the page are also about multiplying. Just remember to do the best you can on this page. All right, begin.

At the end of five minutes, say: Put your pencils down.

Collect the papers.

Add

2 + 5	6 + 0	1 + 7	4 + 4	3 + 2	0 + 9
5 + 4	6 + 1	5 + 0	2 + 7	4 + 6	8 + 5	1 + 9
7 + 4	3 + 8	8 + 6	5 + 5	8 + 4	9 + 3	6 + 8

Subtract

8 − 4	9 − 3	6 − 2	8 − 1	9 − 7	9 − 0
5 − 4	4 − 4	6 − 0	5 − 2	14 − 5	16 − 7	11 − 4
15 − 6	12 − 4	10 − 6	17 − 9	14 − 7	13 − 8	17 − 8

Solve the number sentences.

9 + 2 = ☐	5 − 1 = ☐	☐ = 3+6
☐ = 14−8	3 + ☐ = 7	☐ + 2 = 4
10 = 9 + ☐	12 = ☐ + 7	☐ = 8−3
☐ = 7+4	16−9 = ☐	4 + 0 = ☐
1 = ☐ + 1	6 = 5 + ☐	☐ + 9 = 11
5 + ☐ = 13	☐ −3 = 4	8 − ☐ = 7
5 = 14 − ☐	1 = ☐ − 5	4 = ☐ − 8
0 = 9 − ☐	☐ −4 = 6	10 − ☐ = 3
31+18 = ☐	49+ ☐ = 60	☐ +26 = 44
52−37 = ☐	29− ☐ = 15	☐ −32 = 57

Add

43 +25	27 +62	38 +45	19 +44
265 + 314	503 + 293	174 + 642	426 + 458

Subtract

87 − 51	94 − 60	70 − 39	31 − 15
482 − 231	698 − 457	846 − 393	256 − 138

WRITE THE MISSING NUMBERS.

1. 3 TENS + 4 = ☐

2. 5 TENS + 0 = ☐

3. 6 TENS + 18 = ☐

4. ☐ TENS + 1 = 81

5. 2 TENS + ☐ = 25

6. 4 TENS + ☐ = 56

7. 70 + 7 = ☐

8. 40 + 6 = ☐

9. 30 + 19 = ☐

10. ☐ + 2 = 52

11. 90 + 3 = ☐

12. ☐ + 14 = 74

13. ☐ + ☐ = 47

14. 200 + 50 + 1 = ☐

15. 700 + 60 + 6 = ☐

16. 300 + 140 + 2 = ☐

17. ☐ + 20 + 4 = 424

18. 500 + ☐ + 8 = 508

19. 6 HUNDREDS + 4 TENS + 4 = ☐

20. 1 HUNDRED + 0 TENS + 7 = ☐

WRITE THE MISSING NUMBERS.

1. 77, ___, 79

2. 40, 41, ___, 43

3. 27, 28, ___, ___

4. ___, 53, 54

5. ___, 39, 40

6. ___, ___, 21

7. 304, 305, ___, ___

8. 130, 140, 150, ___, ___

9. 580, 590, ___, ___, 620

10. 687, 688, ___, ___, ___

WRITE THE NUMBERS IN ORDER, SMALLEST FIRST.

17, 13, 21, 27 → ___, ___, ___, ___

194, 109, 914, 401 → ___, ___, ___, ___

88, 808, 188, 806 → ___, ___, ___, ___

CIRCLE THE LARGER NUMBER IN EACH PAIR.

47 308

56 318

24 930

42 93

PUT AN X ON THE SMALLER NUMBER IN EACH PAIR.

126 40

162 48

81 98

57 89

140 WRITE THE PRODUCT.

3	4	8	0	1
x 2	x 5	x 2	x 7	x 4
6	9	8	7	3
x 6	x 2	x 7	x 4	x 9

SOLVE THE NUMBER SENTENCES.

2 x 6 = ☐	5 x ☐ = 30	☐ x 1 = 7
16 = 2 x ☐	8 = ☐ x 4	☐ = 5 x 3
☐ = 9 x 7	8 x ☐ = 48	6 x 7 = ☐
0 = 8 x ☐	☐ x 7 = 49	36 = ☐ x 9

Midyear Test

Third Grade

Instructions for Test Administration of Third Grade Midyear Test--Part I (Day 1)

To the teacher: These are simply suggestions for directions for you. Feel free to paraphrase or use your own words that convey the same meaning. Please observe the time limits carefully.

Distribute the test booklets. Say: Do not turn the page until I tell you to do so. Print your first name and last name on the line.

After the children have written their names, say: On these pages you will be asked to work some math problems. You may find some problems that you cannot do. Don't feel bad about that. The reason you are trying these problems is to help me find out what you do know and what you do not know. All that I ask is that you do the best you can and that you do your own work. Please don't look on any one else's paper.

NOW OPEN TO THE NEXT PAGE

These are addition and subtraction facts. Half of the page is about addition and half is about subtraction. I am going to let you work on this page for two minutes. Work quickly but don't be careless. If you come to a problem you don't know the answer for, don't waste too much time trying to figure it out. Go on to the next one. All right, begin.

At the end of 2 minutes, say: Put your pencils down.

TURN TO THE NEXT PAGE

Look at the directions. The directions say, Solve the Number Sentences. That means that you should figure out what to write in the box to make a true sentence. Use whatever method you want to help you find the right answer. You will have just four minutes to do these so do not waste too much time on a problem you may not be able to do. All right, begin.

At the end of 4 minutes, say: Put your pencils down.

TURN TO THE NEXT PAGE

These problems ask you to add or subtract bigger numbers. You will have only five minutes to do these problems so don't waste too much time on one problem. All right, begin.

At the end of 2 1/2 minutes, say: If you have begun working on the subtraction problems, you should start them now.

At the end of the next 2 1/2 minutes, say: Put your pencils down.

TURN TO THE LAST PAGE

Before you begin this page, let's make sure we all can read the directions. At the top, it says, "Write the Missing Numbers." This means you should write the missing number in the box. In the middle of the page, it says, "Write the Numbers in Order, Smallest First." That means if the four numbers are not already written in order from smallest to largest, you have to re-write them on the little lines, putting the smallest number down first, then going in order so that the largest number is the last one you write. Down at the bottom, the directions are to fill in the blanks. You will have four minutes to work on this page. All right, begin.

At the end of 4 minutes, say: Put your pencils down.

Collect the papers.

Instructions for Test Administration of Third Grade Midyear Test--Part II (Day 2)

To the Teacher: These instructions are suggestions only. Feel free to paraphrase, modify, or amplify the directions to the children. But, please observe the time limits carefully.

Distribute the test booklets. Say: Do not turn the page until I tell you to do so. Print your first name and last name on the line.

After the children have written their names, say: Today you are going to do more math problems. I am asking you to do these because I want to try to find out how much you know and what things you may not know. There may be some problems on the pages that you cannot do. Do not feel bad or disappointed. Just do the best you can and work on the ones you do know how to do. Remember, I want to know what you can do, not what someone else can do. So keep your eyes on your own paper.

NOW OPEN TO THE NEXT PAGE.

These problems ask you to add and subtract bigger numbers. You will have three minutes to do this page. All right, begin.

At the end of 3 minutes, say: Put your pencils down.

TURN TO THE NEXT PAGE.

On this page are some division and some multiplication problems. Some of you may not have done problems like this before. Remember, don't feel bad or disappointed if you can't do them. You will have six minutes to work these problems so don't waste too much time on one problem. All right, begin.

At the end of 3 minutes, say: If you have not yet started on the multiplication problems, you should start on them now.

At the end of the next 3 minutes, say: Put your pencils down.

Collect the papers.

ADD

6 + 9	4 + 5	3 + 8	6 + 4	3 + 5
4 + 3	5 + 8	8 + 9	0 + 7	6 + 1

SUBTRACT

14 - 8	13 - 5	9 - 9	6 - 0	7 - 4
11 - 5	12 - 7	8 - 2	5 - 3	15 - 8

SOLVE THE NUMBER SENTENCES.

$5 + 1 = \square$	$13 - 8 = \square$	$\square = 6 + 5$
$\square = 8 - 3$	$4 + \square = 8$	$\square + 7 = 13$
$16 = 7 + \square$	$7 = \square + 5$	$\square - 4 = 5$
$18 - \square = 9$	$3 = \square - 8$	$6 = 9 - \square$
$52 + 39 = \square$	$34 + \square = 65$	$\square + 43 = 78$
$97 - 64 = \square$	$55 - \square = 38$	$\square - 17 = 63$

ADD

51 + 27	30 + 21	29 + 32	45 + 28
417 + 212	813 + 172	186 + 570	115 + 875

SUBTRACT

88 - 76	56 - 25	72 - 28	83 - 67
915 - 411	634 - 523	726 - 186	388 - 269

WRITE THE MISSING NUMBERS.

1. $6(10) + 3 = \square$

2. $8(10) + 0 = \square$

3. $5(10) + \square = 62$

4. $70 + 4 = \square$

5. $80 + 13 = \square$

6. $\square + 17 = 87$

7. $800 + 10 + 8 = \square$

8. $500 + 190 + 1 = \square$

9. $\square + 30 + 2 = 532$

10. $7(100) + 0(10) + 9 = \square$

WRITE THE NUMBERS IN ORDER, SMALLEST FIRST.

45, 57, 54, 47 → _____, _____, _____, _____

603, 236, 326, 623 → _____, _____, _____, _____

4401, 4040, 440, 4140 → _____, _____, _____, _____

5342, 2435, 3542, 2534 → _____, _____, _____, _____

FILL IN THE BLANKS.

71,248 THE DIGIT _____ IS IN THE THOUSANDS' PLACE.

82,150 THE DIGIT _____ IS IN THE TENS' PLACE.

10,732 THE DIGIT _____ IS IN THE HUNDREDS' PLACE.

35,207 THE DIGIT 3 IS IN THE _____ PLACE.

48,924 THE DIGIT 9 IS IN THE _____ PLACE.

26,798 THE DIGIT 8 IS IN THE _____ PLACE.

ADD

6314	8252	3566
+ 3157	+ 1032	+ 4547

SUBTRACT

9591	3515	5654
- 4540	- 1282	- 3786

DIVIDE

$5\overline{)25}$ $6\overline{)42}$ $4\overline{)36}$ $7\overline{)21}$ $8\overline{)56}$

SOLVE THE NUMBER SENTENCES.

$10 \div 2 = \square$ $72 \div 9 = \square$ $40 \div 8 = \square$

$32 \div 8 = \square$ $54 \div 6 = \square$

MULTIPLY

$$\begin{array}{r} 13 \\ \times\ 3 \\ \hline \end{array} \qquad \begin{array}{r} 24 \\ \times\ 2 \\ \hline \end{array} \qquad \begin{array}{r} 21 \\ \times\ 4 \\ \hline \end{array} \qquad \begin{array}{r} 16 \\ \times\ 7 \\ \hline \end{array}$$

$$\begin{array}{r} 14 \\ \times\ 6 \\ \hline \end{array} \qquad \begin{array}{r} 22 \\ \times\ 5 \\ \hline \end{array} \qquad \begin{array}{r} 53 \\ \times\ 7 \\ \hline \end{array} \qquad \begin{array}{r} 26 \\ \times\ 2 \\ \hline \end{array}$$

Spring Posttest

Third Grade

Instructions for Test Administration of Third Grade End-of-Year Test--Part 1 (Day 1)

To the teacher: These are simply suggestions for directions for you. Feel free to paraphrase or use your own words that convey the same meaning. Please observe the time limits carefully.

Distribute the test booklets. Say: Do not turn the page until I tell you to do so. Print your first name and last name on the line.

After the children have written their names, say: On these pages you will be asked to work some math problems. You may find some problems that you cannot do. Don't feel bad about that. The reason you are trying these problems is to help me find out what you do know and what you do not know. All that I ask is that you do the best you can and that you do your own work. Please don't look on any one else's paper.

NOW OPEN TO THE NEXT PAGE

These are addition and subtraction facts. Half of the page is about addition and half is about subtraction. I am going to let you work on this page for two minutes. Work quickly but don't be careless. If you come to a problem you don't know the answer for, don't waste too much time trying to figure it out. Go on to the next one. All right, begin.

At the end of 2 minutes, say: Put your pencils down.

TURN TO THE NEXT PAGE

Look at the directions. The directions say, Solve the Number Sentences. That means that you should figure out what to write in the box to make a true sentence. Use whatever method you want to help you find the right answer. You will have just four minutes to do these so do not waste too much time on a problem you may not be able to do. All right, begin.

At the end of 4 minutes, say: Put your pencils down.

TURN TO THE NEXT PAGE

These problems ask you to add or subtract bigger numbers. You will have only five minutes to do these problems so don't waste too much time on one problem. All right, begin.

At the end of 2 1/2 minutes, say: If you have begun working on the subtraction problems, you should start them now.

At the end of the next 2 1/2 minutes, say: Put your pencils down.

TURN TO THE LAST PAGE

Before you begin this page, let's make sure we all can read the directions. At the top, it says, "Write the Missing Numbers." This means you should write the missing number in the box. In the middle of the page, it says, "Write the Numbers in Order, Smallest First." That means if the four numbers are not already written in order from smallest to largest, you have to re-write them on the little lines, putting the smallest number down first, then going in order so that the largest number is the last one you write. Down at the bottom, the directions are to fill in the blanks. You will have four minutes to work on this page. All right, begin.

At the end of 4 minutes, say: Put your pencils down.

Collect the papers.

Instructions for Test Administration of Third Grade End-of-Year Test--Part II (Day 2)

To the teacher: These instructions are suggestions only. Feel free to paraphrase, modify, or amplify the directions to the children. But, please observe the time limits carefully.

Distribute the test booklets. Say: Do not turn the page until I tell you to do so. Print your first name and last name on the line.

After the children have written their names, say: Today you are going to do more math problems. I am asking you to do these because I want to try to find out how much you know and what things you may not know. There may be some problems on the pages that you cannot do. Do not feel bad or disappointed. Just do the best you can and work on the ones you do know how to do. Remember, I want to know what you can do, not what someone else can do. So keep your eyes on your own paper.

NOW OPEN TO THE NEXT PAGE

These problems ask you to add and subtract bigger numbers. You will have three minutes to do this page, All right, begin.

At the end of 3 minutes, say: Put your pencils down.

TURN TO THE NEXT PAGE

On this page are some multiplication problems. Some of you may not have done problems like this before. Remember, don't feel bad or disappointed if you can't do them. You will have five minutes to work these problems so don't waste too much time on one problem. All right, begin.

At the end of 5 minutes, say: Put your pencils down.

TURN TO THE LAST PAGE

On this page are some division problems. Some of you may not have done problems like this before. Just do the best you can on them. You will have three minutes to work on this page. All right, begin.

At the end of 3 minutes, say: Put your pencils down.

Collect the papers.

ADD

8 + 3	6 + 1	6 + 6	5 + 3	9 + 4
2 + 5	5 + 7	4 + 3	8 + 6	0 + 9

SUBTRACT

7 - 4	13 - 4	8 - 6	17 - 8	15 - 8
10 - 7	18 - 9	8 - 3	2 - 0	6 - 4

SOLVE THE NUMBER SENTENCES.

$7 + 1 = \square$ $\quad$ $12 - 7 = \square$ $\quad$ $\square = 9 + 2$

$\square = 6 - 4$ $\quad$ $6 + \square = 9$ $\quad$ $\square + 8 = 17$

$13 = 6 + \square$ $\quad$ $8 = \square + 3$ $\quad$ $\square - 5 = 4$

$13 - \square = 8$ $\quad$ $7 = \square - 8$ $\quad$ $2 = 7 - \square$

$65 + 27 = \square$ $\quad$ $25 + \square = 57$ $\quad$ $\square + 52 = 88$

$39 - 16 - \square$ $\quad$ $68 - \square = 29$ $\quad$ $\square - 16 = 34$

ADD

14 + 84	52 + 45	24 + 26	36 + 48
332 + 246	683 + 215	155 + 792	239 + 653

SUBTRACT

98 - 25	79 - 41	83 - 27	72 - 63
582 - 232	998 - 676	614 - 384	864 - 225

WRITE THE MISSING NUMBERS.

1. 3 TENS + ☐ = 36

2. ☐ TENS + 0 = 50

3. 7 TENS + 15 = ☐

4. 20 + ☐ = 29

5. 60 + ☐ = 78

6. ☐ + 18 = 28

7. ☐ + 20 + 3 = 623

8. 600 + 120 + 1 = ☐

9. 400 + 50 + 8 = ☐

10. 4 HUNDREDS + 0 TENS + 7 = ☐

WRITE THE NUMBERS IN ORDER, SMALLEST FIRST.

64, 46, 60, 40 _____, _____, _____, _____

599, 619, 615, 519 _____, _____, _____, _____

3333, 3033, 3003, 3030 _____, _____, _____, _____

7696, 7966, 9676, 6789 _____, _____, _____, _____

FILL IN THE BLANKS.

92,765 THE DIGIT _____ IS IN THE ONES' PLACE.

31,205 THE DIGIT _____ IS IN THE HUNDREDS' PLACE.

84,362 THE DIGIT _____ IS IN THE TEN THOUSANDS' PLACE.

39,651 THE DIGIT 5 IS IN THE _____ PLACE.

23,546 THE DIGIT 3 IS IN THE _____ PLACE.

46,573 THE DIGIT 5 IS IN THE _____ PLACE.

ADD

5384	2546	2998
+ 2431	+ 3301	+ 1612

SUBTRACT

8078	8257	6432
- 4047	- 5654	- 2546

WRITE THE PRODUCT.

8 x 2	5 x 6	6 x 7	4 x 8	8 x 9
7 x 3	0 x 6	9 x 9	5 x 1	9 x 7

MULTIPLY

23 x 2	12 x 3	78 x 1	15 x 5
27 x 3	64 x 6	83 x 5	53 x 2

DIVIDE

$6\overline{)48}$ $3\overline{)18}$ $8\overline{)24}$ $7\overline{)35}$ $9\overline{)63}$

SOLVE THE NUMBER SENTENCES.

$56 \div 7 =$ ☐ $36 \div 6 =$ ☐ $27 \div 9 =$ ☐

$40 \div 8 =$ ☐ $8 \div 2 =$ ☐

Short Tests

Second Grade

Add

4	7	9	4	6	9
+ 3	+ 8	+ 0	+ 4	+ 5	+ 3

Subtract

9	12	10	8	14	5
- 7	- 6	- 4	- 8	- 9	- 2

Solve the number sentences.

5 - ☐ = 0 7 = ☐ + 1 ☐ - 9 = 8

☐ = 7 - 4 12 = 3 + ☐ 5 + 8 = ☐

Test No. 1

October 21, 1977

ADD

9	4	4	0	9	3
+ 1	+ 7	+ 5	+ 4	+ 8	+ 2

SUBTRACT

15	8	16	12	7	7
- 8	- 5	- 9	- 3	- 0	- 6

SOLVE THE NUMBER SENTENCES.

5 + ☐ = 12 8 = ☐ - 8 ☐ + 2 = 2

☐ = 8 + 3 6 = 7 - ☐ 8 - 4 = ☐

Test No. 2

November 10, 1977

ADD

8	7	7	1	5	9
+ 0	+ 6	+ 3	+ 6	+ 3	+ 5

SUBTRACT

5	18	11	8	9	10
- 5	- 9	- 4	- 1	- 8	- 5

SOLVE THE NUMBER SENTENCES.

$\square = 8 - 1$ $\qquad \square - 5 = 9$ $\qquad 4 = \square + 0$

$4 + 8 = \square$ $\qquad 9 - \square = 4$ $\qquad 15 = 7 + \square$

Test No. 3

November 30, 1977

170

ADD

2	3	0	9	4	4
+ 9	+ 5	+ 6	+ 7	+ 8	+ 2

SUBTRACT

10	8	14	7	9	13
- 8	- 0	- 9	- 3	- 7	- 5

SOLVE THE NUMBER SENTENCES.

14 - ☐ = 8 ☐ - 7 = 0 15 = ☐ + 7

9 = 4 + ☐ ☐ = 17 - 8 6 + 2 = ☐

Test No. 4

December 20, 1977

ADD

6	4	5	2	7	6
+ 4	+ 5	+ 8	+ 4	+ 5	+ 3

SUBTRACT

6	8	12	10	16	9
- 6	- 3	- 5	- 3	- 7	- 4

SOLVE THE NUMBER SENTENCES.

0 + ☐ = 8 ☐ + 9 = 11 10 - 5 = ☐

6 = 13 - ☐ 3 = ☐ - 1 ☐ = 5 + 3

Test No. 5

January 24, 1978

ADD

32	47	19
+ 62	+ 48	+ 34

SUBTRACT

56	92	55
- 33	- 35	- 16

Test No. 5

January 24, 1978

ADD

5	8	3	2	8	4
+8	+6	+3	+7	+2	+5

SUBTRACT

16	12	8	13	7	4
- 9	- 7	- 7	- 9	- 2	- 4

SOLVE THE NUMBER SENTENCES.

6 + ☐ = 9 ☐ - 4 = 8 8 - 6 = ☐

12 = 6 + ☐ 11 = ☐ + 3 ☐ = 5 + 1

Test No. 6

February 16, 1978

ADD

24 + 70	33 + 58	27 + 38

SUBTRACT

39 - 38	90 - 28	63 - 19

Test No. 6

February 16, 1978

WRITE THE MISSING NUMBERS.

5 TENS + 2 = ☐

3 TENS + 0 = ☐

4 TENS + 13 = ☐

☐ TENS + 3 = 73

6 TENS + ☐ = 64

2 TENS + ☐ = 39

50 + 1 = ☐

70 + 8 = ☐

40 + 15 = ☐

☐ + 6 = 46

80 + 7 = ☐

☐ + 16 = 36

WRITE THE MISSING NUMBERS.

43, ____, 45

90, ____, 92, 93

____, ____, 61, 62

36, 37, ____

28, 29, ____

79, ____, 81

Test No. 6

February 16, 1978

176

ADD

9	4	5	3	8	8
+ 5	+ 3	+ 5	+ 5	+ 4	+ 0

SUBTRACT

9	11	8	7	16	15
- 9	- 2	- 2	- 4	- 7	- 6

SOLVE THE NUMBER SENTENCES.

17 - ☐ = 8 ☐ - 4 = 2 4 + 5 = ☐

6 = 6 + ☐ 12 = ☐ + 7 ☐ = 16 - 8

Test No. 7

March 6, 1978

ADD

50 + 33	35 + 19	65 + 15

SUBTRACT

69 - 17	31 - 13	74 - 48

Test No. 7

March 6, 1978

178

WRITE THE MISSING NUMBERS.

$8(10) + 8 = \square$

$7(10) + 0 = \square$

$2(10) + 10 = \square$

$\square (10) + 5 = 45$

$9(10) + \square = 97$

$6(10) + \square = 78$

$60 + 5 = \square$

$40 + 1 = \square$

$50 + 12 = \square$

$\square + 7 = 37$

$20 + 4 = \square$

$\square + 18 + 48$

WRITE THE MISSING NUMBERS.

58, 59, _____, _____

69, _____, _____, 72

_____, 33, 34

75, 76, _____

80, _____, 82

_____, 19, 20

SOLVE THE NUMBER SENTENCES.

$9 - \square = 6$ $\square + 8 = 14$ $15 - 9 = \square$

$14 = 7 + \square$ $8 = \square - 1$ $\square = 3 + 5$

ADD

$$\begin{array}{r} 65 \\ +\ 30 \\ \hline \end{array} \qquad \begin{array}{r} 68 \\ +\ 22 \\ \hline \end{array} \qquad \begin{array}{r} 17 \\ +\ 47 \\ \hline \end{array}$$

$$\begin{array}{r} 661 \\ +\ 231 \\ \hline \end{array} \qquad \begin{array}{r} 753 \\ +\ 152 \\ \hline \end{array} \qquad \begin{array}{r} 468 \\ +\ 325 \\ \hline \end{array}$$

Test No. 8

March 23, 1978

WRITE THE MISSING NUMBERS.

7 TENS + 6 = ☐

5 TENS + 0 = ☐

3 TENS + ☐ = 40

☐ TENS + 3 = 63

6 TENS + ☐ = 65

3 TENS + ☐ = 44

40 + ☐ = 47

☐ + 6 = 46

☐ + 13 = 63

80 + ☐ = 87

50 + 1 = ☐

60 + 12 = ☐

WRITE THE MISSING NUMBERS.

17, 18, _____, _____

_____, 80, _____

36, _____, _____, 39

55, 56, _____, 58

_____, 41, 42

60, _____, 62, _____

SUBTRACT

58 - 26	83 - 35	66 - 29

WRITE THE PRODUCT.

6 x 5	4 x 2	3 x 8	6 x 8	9 x 2	3 x 4

Test No. 8

March 23, 1978

SOLVE THE NUMBER SENTENCES

$9 + \square = 13$ $\quad 9 = \square - 2$ $\quad 0 + 7 = \square$

$3 = 7 - \square$ $\quad \square + 2 = 6$ $\quad \square = 15 - 8$

ADD

25 + 71	49 + 29	38 + 15
156 + 443	802 + 189	341 + 575

Test No. 9

April 21, 1978

SUBTRACT

$$\begin{array}{r} 98 \\ -\ 47 \\ \hline \end{array} \qquad \begin{array}{r} 53 \\ -\ 24 \\ \hline \end{array} \qquad \begin{array}{r} 60 \\ -\ 31 \\ \hline \end{array}$$

SOLVE THE NUMBER SENTENCES.

$8(4) = \square$ $\qquad 0(7) = \square$ $\qquad 6(3) = \square$

$1(5) = \square$ $\qquad 6(9) = \square$ $\qquad 7(7) = \square$

Test No. 9

April 21, 1978

WRITE THE MISSING NUMBERS.

$5(10) + \square = 59$

$4(10) + \square = 40$

$\square (10) + 16 = 76$

$2(10) + 8 = \square$

$3(10) + 8 = \square$

$\square (10) + 10 = 60$

$\square + 3 = 83$

$20 + \square = 21$

$30 + \square = 45$

$50 + 2 = \square$

$\square + 3 = 73$

$\square + 14 = 84$

WRITE THE MISSING NUMBERS.

_____, 21, 22

89, _____, _____, 92

48, _____, 50

_____, 33, 34, _____

69, _____, 71

_____, _____, 10, 11

Short Tests

Third Grade

ADD

4	7	9	4	6	9
+ 3	+ 8	+ 0	+ 4	+ 5	+ 3

SUBTRACT

9	12	10	8	14	5
- 7	- 6	- 4	- 8	- 9	- 2

SOLVE THE NUMBER SENTENCES

5 - ☐ = 0 　　7 = ☐ + 1 　　☐ - 9 = 8

☐ = 7 - 4 　　12 = 3 + ☐ 　　5 + 8 = ☐

Test No. 1

October 21, 1977

ADD

36	87	529
+ 37	+ 10	+ 315

SUBTRACT

98	31	795
- 12	- 15	- 673

WRITE THE MISSING NUMBERS.

4(10) + 8 = ☐

7(10) + ☐ = 83

50 + 16 = ☐

☐ + 5 = 45

☐ + 60 + 9 = 9

2(100) + 4(10) + 7 = ☐

SOLVE THE NUMBER SENTENCES.

4(6) = ☐

9(5) = ☐

3(2) = ☐

4(5) = ☐

7(8) = ☐

2(9) = ☐

ADD

9	4	4	0	9	3
+ 1	+ 7	+ 5	+ 4	+ 8	+ 2

SUBTRACT

15	8	16	12	7	7
- 8	- 5	- 9	- 3	- 0	- 6

SOLVE THE NUMBER SENTENCES.

5 + ☐ = 12 8 = ☐ - 8 ☐ + 2 = 2

☐ = 8 + 3 6 = 7 - ☐ 8 - 4 = ☐

Test No. 2

November 10, 1977

ADD

18 + 32	44 + 11	522 + 371

SUBTRACT

68 - 40	86 - 17	754 - 339

WRITE THE MISSING NUMBERS.

3 TENS + 16 = ☐

☐ TENS + 7 = 57

40 + 4 = ☐

☐ + ☐ = 21

300 + 40 + 3 = ☐

8 HUNDREDS + 0 TENS + 9 = ☐

WRITE THE PRODUCT.

6 x 3	8 x 8	4 x 7	6 x 5	0 x 5	7 x 9

Test No. 2

November 10, 1977

ADD

8 + 0	7 + 6	7 + 3	1 + 6	5 + 3	9 + 5

SUBTRACT

5 - 5	18 - 9	11 - 4	8 - 1	9 - 8	10 - 5

SOLVE THE NUMBER SENTENCES.

$\square = 8 - 1$ $\qquad \square - 5 = 9$ $\qquad 4 = \square + 0$

$4 + 8 = \square$ $\qquad 9 - \square = 4$ $\qquad 15 = 7 + \square$

Test No. 3

November 30, 1977

ADD

37	86	110
+ 24	+ 42	+ 382

SUBTRACT

76	45	951
- 33	- 39	- 718

WRITE THE MISSING NUMBERS.

8(10) + 0 = ☐ 3(10) + ☐ = 34

60 + 6 = ☐ ☐ + 19 = 59

500 + 120 + 3 = ☐ 600 + ☐ + 5 = 605

SOLVE THE NUMBER SENTENCES.

4(8) = ☐ 5(7) = ☐ 8(1) = ☐

8(9) = ☐ 2(6) = ☐ 7(3) = ☐

ADD

97 + 24	21 + 48	754 + 166	216 + 283

SUBTRACT

893 - 153	421 - 306	970 - 438
334 - 171	316 - 224	624 - 358

Test No. 4

December 20, 1977

(Falk School did not have 2-digit addition.)

SOLVE THE NUMBER SENTENCES.

$7(8) = \square$ $\quad 0(4) = \square$ $\quad 5(5) = \square$

$4(9) = \square$ $\quad 6(3) = \square$ $\quad 7(4) = \square$

SOLVE THE NUMBER SENTENCES.

$\square(2) = 16$ $\quad \square(7) = 42$ $\quad 3(\square) = 21$

$9(\square) = 54$ $\quad \square(4) = 4$ $\quad 5(\square) = 40$

Test No. 4

December 20, 1977

ADD

19 + 80	65 + 29	452 + 176	241 + 138

SUBTRACT

967 - 655	546 - 327	863 - 148
407 - 125	627 - 364	534 - 138

Test No. 5

January 24, 1978

(Falk School did not have 2-digit addition.)

SOLVE THE NUMBER SENTENCES.

$7(7) = \square$ $\quad 9(3) = \square$ $\quad 8(1) = \square$

$5(8) = \square$ $\quad 0(7) = \square$ $\quad 3(4) = \square$.

SOLVE THE NUMBER SENTENCES.

$\square(7) = 56$ $\quad \square(9) = 45$ $\quad 4(\square) = 28$

$2(\square) = 18$ $\quad \square(4) = 24$ $\quad 7(\square) = 7$.

Test No. 5

January 24, 1978

ADD

$$\begin{array}{r} 1703 \\ +\ 6396 \\ \hline \end{array} \qquad \begin{array}{r} 3665 \\ +\ 1065 \\ \hline \end{array}$$

SUBTRACT

$$\begin{array}{r} 8226 \\ -\ 3875 \\ \hline \end{array} \qquad \begin{array}{r} 5784 \\ -\ 2431 \\ \hline \end{array}$$

SOLVE THE NUMBER SENTENCES.

$2 (6) = \square$ $\quad 7 (8) = \square$ $\quad 5 (9) = \square$

$3 (6) = \square$ $\quad 4 (7) = \square$ $\quad 8 (4) = \square$

SOLVE THE NUMBER SENTENCES.

$\square (5) = 20$ $\quad \square (6) = 36$ $\quad 3 (\square) = 21$

$7 (\square) = 63$ $\quad \square (4) = 12$ $\quad 6 (\square) = 48$

Test No. 6, Orchard Ridge School

February 16, 1978

WRITE THE MISSING NUMBERS.

$5(10) + 12 = \square$ $\qquad$ $\square(10) + 3 = 43$

$7(10) + \square = 76$ $\qquad$ $300 + 60 + 2 = \square$

$200 + \square + 5 = 205$ $\qquad$ $4(100) + 2(10) + 9 = \square$.

FILL IN THE BLANKS.

58,372 THE DIGIT _____ IS IN THE HUNDREDS' PLACE.

27,381 THE DIGIT _____ IS IN THE TEN THOUSANDS' PLACE.

38,920 THE DIGIT _____ IS IN THE ONES' PLACE.

68,907 THE DIGIT 8 IS IN THE _____ PLACE.

82,639 THE DIGIT 3 IS IN THE _____ PLACE.

36,428 THE DIGIT 4 IS IN THE _____ PLACE.

ADD

$$\begin{array}{r} 1703 \\ +\ 6396 \\ \hline \end{array} \qquad \begin{array}{r} 3665 \\ +\ 1065 \\ \hline \end{array}$$

SUBTRACT

$$\begin{array}{r} 8226 \\ -\ 3875 \\ \hline \end{array} \qquad \begin{array}{r} 5784 \\ -\ 2431 \\ \hline \end{array}$$

WRITE THE PRODUCT.

$$\begin{array}{r} 2 \\ \times 6 \\ \hline \end{array} \quad \begin{array}{r} 7 \\ \times 8 \\ \hline \end{array} \quad \begin{array}{r} 5 \\ \times 9 \\ \hline \end{array} \quad \begin{array}{r} 3 \\ \times 6 \\ \hline \end{array} \quad \begin{array}{r} 4 \\ \times 7 \\ \hline \end{array} \quad \begin{array}{r} 8 \\ \times 4 \\ \hline \end{array}$$

SOLVE THE NUMBER SENTENCES.

$\square \times 5 = 20$ $\square \times 6 = 36$ $3 \times \square = 21$

$7 \times \square = 63$ $\square \times 4 = 12$ $6 \times \square = 48$

Test No. 6, Falk School

February 16, 1978

DIVIDE

$2\overline{)16}$ $6\overline{)30}$ $7\overline{)49}$ $9\overline{)63}$ $4\overline{)8}$

SOLVE THE NUMBER SENTENCES.

$42 \div 6 = \square$ $54 \div 6 = \square$ $25 \div 5 = \square$.

$18 \div 9 = \square$ $32 \div 8 = \square$

MULTIPLY

$$\begin{array}{r} 33 \\ \times\ 2 \\ \hline \end{array} \qquad \begin{array}{r} 84 \\ \times\ 1 \\ \hline \end{array} \qquad \begin{array}{r} 13 \\ \times\ 3 \\ \hline \end{array} \qquad \begin{array}{r} 14 \\ \times\ 2 \\ \hline \end{array}$$

$$\begin{array}{r} 23 \\ \times\ 4 \\ \hline \end{array} \qquad \begin{array}{r} 21 \\ \times\ 5 \\ \hline \end{array} \qquad \begin{array}{r} 36 \\ \times\ 2 \\ \hline \end{array} \qquad \begin{array}{r} 53 \\ \times\ 8 \\ \hline \end{array}$$

Test No. 6, Falk School

February 16, 1978

ADD

$$\begin{array}{r} 5495 \\ +\ 3412 \\ \hline \end{array} \qquad \begin{array}{r} 1875 \\ +\ 2508 \\ \hline \end{array}$$

SUBTRACT

$$\begin{array}{r} 9691 \\ -\ 6411 \\ \hline \end{array} \qquad \begin{array}{r} 6890 \\ -\ 5062 \\ \hline \end{array}$$

SOLVE THE NUMBER SENTENCES.

$5(1) = \square$ $\quad 3(7) = \square$ $\quad 7(6) = \square$

$6(9) = \square$ $\quad 4(8) = \square$ $\quad 6(3) = \square$

SOLVE THE NUMBER SENTENCES.

$\square(9) = 81$ $\quad \square(6) = 24$ $\quad 8(\square) = 56$

$4(\square) = 28$ $\quad \square(7) = 35$ $\quad 2(\square) = 16$

Test No. 7, Orchard Ridge School

March 6, 1978

WRITE THE MISSING NUMBERS.

60 + 6 = ☐

2(10) + ☐ = 32

☐ + ☐ = 58

☐ + 1 = 71

☐ + 70 + 3 = 273

500 + 180 + 3 = ☐

FILL IN THE BLANKS.

73,629 THE DIGIT _____ IS IN THE TENS' PLACE.

32,458 THE DIGIT _____ IS IN THE THOUSANDS' PLACE.

17,549 THE DIGIT _____ IS IN THE HUNDRED' PLACE.

72,563 THE DIGIT 3 IS IN THE _____ PLACE.

31,609 THE DIGIT 0 IS IN THE _____ PLACE.

23,456 THE DIGIT 2 IS IN THE _____ PLACE.

ADD

$$\begin{array}{r} 5495 \\ +\ 3412 \\ \hline \end{array} \qquad \begin{array}{r} 1875 \\ +\ 2508 \\ \hline \end{array}$$

SUBTRACT

$$\begin{array}{r} 9691 \\ -\ 6411 \\ \hline \end{array} \qquad \begin{array}{r} 6890 \\ -\ 5062 \\ \hline \end{array}$$

WRITE THE PRODUCT.

$$\begin{array}{r} 5 \\ \times 1 \\ \hline \end{array} \quad \begin{array}{r} 3 \\ \times 7 \\ \hline \end{array} \quad \begin{array}{r} 7 \\ \times 6 \\ \hline \end{array} \quad \begin{array}{r} 6 \\ \times 9 \\ \hline \end{array} \quad \begin{array}{r} 4 \\ \times 8 \\ \hline \end{array} \quad \begin{array}{r} 6 \\ \times 3 \\ \hline \end{array}$$

SOLVE THE NUMBER SENTENCES.

$\square \times 9 = 81$ $\qquad \square \times 6 = 24$ $\qquad 8 \times \square = 56$

$4 \times \square = 28$ $\qquad \square \times 7 = 35$ $\qquad 2 \times \square = 16$

Test No. 7, Falk School

March 6, 1978

DIVIDE

$6\overline{)36}$ $8\overline{)48}$ $2\overline{)8}$ $9\overline{)72}$ $3\overline{)15}$

SOLVE THE NUMBER SENTENCES.

$49 \div 7 = \square$ $21 \div 7 = \square$ $45 \div 9 = \square$

$32 \div 8 = \square$ $6 \div 3 = \square$

MULTIPLY

$$\begin{array}{r} 13 \\ \times\ 2 \\ \hline \end{array} \qquad \begin{array}{r} 44 \\ \times\ 2 \\ \hline \end{array} \qquad \begin{array}{r} 20 \\ \times\ 3 \\ \hline \end{array} \qquad \begin{array}{r} 21 \\ \times\ 4 \\ \hline \end{array}$$

$$\begin{array}{r} 25 \\ \times\ 3 \\ \hline \end{array} \qquad \begin{array}{r} 32 \\ \times\ 4 \\ \hline \end{array} \qquad \begin{array}{r} 21 \\ \times\ 6 \\ \hline \end{array} \qquad \begin{array}{r} 47 \\ \times\ 5 \\ \hline \end{array}$$

Test No. 7, Falk School

March 8, 1978

ADD

$$\begin{array}{r} 6861 \\ +\ 2764 \\ \hline \end{array} \qquad \begin{array}{r} 4097 \\ +\ 1305 \\ \hline \end{array}$$

SUBTRACT

$$\begin{array}{r} 7382 \\ -\ 5933 \\ \hline \end{array} \qquad \begin{array}{r} 9419 \\ -\ 6909 \\ \hline \end{array}$$

SOLVE THE NUMBER SENTENCES.

$6(5) = \square$ $\quad 4(2) = \square$ $\quad 3(8) = \square$

$6(8) = \square$ $\quad 9(2) = \square$ $\quad 3(4) = \square$

SOLVE THE NUMBER SENTENCES.

$\square(9) = 27$ $\quad \square(7) = 7$ $\quad 4(\square) = 36$

$8(\square) = 40$ $\quad \square(9) = 0$ $\quad 9(\square) = 36$

Test No. 8, Orchard Ridge School

March 23, 1978

WRITE THE MISSING NUMBERS.

$50 + 16 = \square$

$2(100) + 0(10) + 6 = \square$

$800 + \square + 2 = 972$

$5(\square) + 3 = 53$

$3(10) + 0 = \square$

$70 + 5 = \square$

FILL IN THE BLANKS.

23,415 THE DIGIT _____ IS IN THE ONES' PLACE.

92,753 THE DIGIT _____ IS IN THE TEN THOUSANDS' PLACE.

61,928 THE DIGIT _____ IS IN THE HUNDREDS' PLACE.

59,042 THE DIGIT 4 IS IN THE _____ PLACE.

48,237 THE DIGIT 4 IS IN THE _____ PLACE.

59,284 THE DIGIT 9 IS IN THE _____ PLACE.

ADD

$$\begin{array}{r} 6861 \\ +\ 2764 \\ \hline \end{array} \qquad \begin{array}{r} 4097 \\ +\ 1305 \\ \hline \end{array}$$

SUBTRACT

$$\begin{array}{r} 7382 \\ -\ 5933 \\ \hline \end{array} \qquad \begin{array}{r} 9419 \\ -\ 6909 \\ \hline \end{array}$$

WRITE THE PRODUCT.

$$\begin{array}{r} 6 \\ \times 5 \\ \hline \end{array} \quad \begin{array}{r} 4 \\ \times 2 \\ \hline \end{array} \quad \begin{array}{r} 3 \\ \times 8 \\ \hline \end{array} \quad \begin{array}{r} 6 \\ \times 8 \\ \hline \end{array} \quad \begin{array}{r} 9 \\ \times 2 \\ \hline \end{array} \quad \begin{array}{r} 3 \\ \times 4 \\ \hline \end{array}$$

SOLVE THE NUMBER SENTENCES.

$\square \times 9 = 27$ $\qquad \square \times 7 = 7$ $\qquad 4 \times \square = 36$

$8 \times \square = 40$ $\qquad \square \times 9 = 0$ $\qquad 9 \times \square = 36$

Test No. 8, Falk School

March 23, 1978

DIVIDE

$8\overline{)24}$ $5\overline{)35}$ $4\overline{)12}$ $9\overline{)54}$ $7\overline{)42}$

SOLVE THE NUMBER SENTENCES.

$10 \div 2 =$ ☐ $81 \div 9 =$ ☐ $27 \div 9 =$ ☐

$20 \div 4 =$ ☐ $56 \div 8 =$ ☐

MULTIPLY

$$\begin{array}{r} 11 \\ \times\ 7 \\ \hline \end{array} \qquad \begin{array}{r} 21 \\ \times\ 4 \\ \hline \end{array} \qquad \begin{array}{r} 40 \\ \times\ 2 \\ \hline \end{array} \qquad \begin{array}{r} 23 \\ \times\ 2 \\ \hline \end{array}$$

$$\begin{array}{r} 26 \\ \times\ 3 \\ \hline \end{array} \qquad \begin{array}{r} 53 \\ \times\ 3 \\ \hline \end{array} \qquad \begin{array}{r} 94 \\ \times\ 2 \\ \hline \end{array} \qquad \begin{array}{r} 53 \\ \times\ 6 \\ \hline \end{array}$$

Test No. 8, Falk School

March 23, 1978

ADD

$$\begin{array}{r} 4409 \\ +\ 2666 \\ \hline \end{array} \qquad \begin{array}{r} 5752 \\ +\ 1624 \\ \hline \end{array}$$

SUBTRACT

$$\begin{array}{r} 8264 \\ -\ 3837 \\ \hline \end{array} \qquad \begin{array}{r} 2431 \\ -\ 1565 \\ \hline \end{array}$$

SOLVE THE NUMBER SENTENCES.

$7(3) = \square$ $\quad 9(3) = \square$ $\quad 5(8) = \square$

$1(9) = \square$ $\quad 6(0) = \square$ $\quad 4(7) = \square$

SOLVE THE NUMBER SENTENCES.

$\square(7) = 14$ $\quad \square(6) = 36$ $\quad 9(\square) = 45$

$9(\square) = 72$ $\quad \square(9) = 54$ $\quad 5(\square) = 25$

Test No. 9, Orchard Ridge

April 21, 1978

WRITE THE MISSING NUMBERS.

$\square$ (10) + 13 = 53

9(100) + $\square$ (10) + 3 = 943

6(10) + 2 = $\square$

$\square$ + 4 = 34

$\square$ + 30 + 7 = 837

200 + 160 + 0 = $\square$

FILL IN THE BLANKS.

81,265 THE DIGIT _____ IS IN THE HUNDREDS' PLACE.

43,061 THE DIGIT _____ IS IN THE TEN THOUSANDS' PLACE.

61,985 THE DIGIT _____ IS IN THE TENS' PLACE.

27,645 THE DIGIT 5 IS IN THE _____ PLACE.

68,039 THE DIGIT 3 IS IN THE _____ PLACE.

14,753 THE DIGIT 4 IS IN THE _____ PLACE.

Test No. 9, Orchard Ridge

April 21, 1978

ADD

$$\begin{array}{r} 4409 \\ +\ 2666 \\ \hline \end{array} \qquad \begin{array}{r} 5752 \\ +\ 1624 \\ \hline \end{array}$$

SUBTRACT

$$\begin{array}{r} 8264 \\ -\ 3837 \\ \hline \end{array} \qquad \begin{array}{r} 2431 \\ -\ 1565 \\ \hline \end{array}$$

SOLVE THE NUMBER SENTENCES.

$\square \times 7 = 14$ $\square \times 6 = 36$ $9 \times \square = 45$

$9 \times \square = 72$ $\square \times 9 = 54$ $5 \times \square = 25$

Test No. 9, Falk School

April 21, 1978

212

DIVIDE

$5\overline{)15}$ $8\overline{)56}$ $3\overline{)21}$ $5\overline{)45}$ $4\overline{)24}$

SOLVE THE NUMBER SENTENCES.

$63 \div 7 = \square$ $32 \div 8 = \square$ $8 \div 1 = \square$

$12 \div 3 = \square$ $40 \div 8 = \square$

MULTIPLY

$$\begin{array}{r} 30 \\ \times\ 3 \\ \hline \end{array} \qquad \begin{array}{r} 32 \\ \times\ 2 \\ \hline \end{array} \qquad \begin{array}{r} 11 \\ \times\ 5 \\ \hline \end{array} \qquad \begin{array}{r} 12 \\ \times\ 4 \\ \hline \end{array}$$

$$\begin{array}{r} 17 \\ \times\ 5 \\ \hline \end{array} \qquad \begin{array}{r} 31 \\ \times\ 7 \\ \hline \end{array} \qquad \begin{array}{r} 83 \\ \times\ 3 \\ \hline \end{array} \qquad \begin{array}{r} 75 \\ \times\ 4 \\ \hline \end{array}$$

Test No. 9, Falk School

April 21, 1978

WRITE THE MISSING NUMBERS.

☐ TENS + 13 = 53

9 HUNDREDS + ☐ TENS + 3 = 943

6 TENS + 2 = ☐

☐ + 4 = 34

☐ + 30 + 7 = 837

200 + 160 + 0 = ☐

FILL IN THE BLANKS.

81,265 THE DIGIT _____ IS IN THE HUNDREDS' PLACE.

43,061 THE DIGIT _____ IS IN THE TEN THOUSANDS' PLACE.

61,985 THE DIGIT _____ IS IN THE TENS' PLACE.

27,645 THE DIGIT 5 IS IN THE _____ PLACE.

68,039 THE DIGIT 3 IS IN THE _____ PLACE.

14,753 THE DIGIT 4 IS IN THE _____ PLACE.

Test No. 9, Falk School

April 21, 1978

APPENDIX B

Specific Suggestions to Teachers on How to Use Calculator with Daily Lessons

Specific Calculator Suggestions

Houghton Mifflin Grade 2

Rather than repeat them for each page or set of pages, the suggestions for free explorations, flash card practice with basic facts, and the playing of games are set forth here one time only with the hope that they are used as frequently as possible.

Page	Suggestions
35-50	Check all exercises.
51	Check exercises using constant addend and constant subtrahend.
52,53,54	No checking of work.
55-60	Because of nature of pages, no suggestions other than free exploration.
61-92	Since this is basically a chapter on geometry and measurement, no specific suggestions are given for these pages. Free exploration and flash card work with basic facts is encouraged from time to time.
93	No particular calculator use.
94	Repeated counting by 10 on the calculator may help with some of the conceptual development contained in this and some of the following pages.
95-98	See suggestion for page 94.
99,100	Work on these pages lend themselves nicely to checking by use of the constant addend of 1.
101,102	Secret code makes checking unnecessary.
103-106	Check all exercises.
107-108	Somewhat complicated page layout makes checking inadvisable.
109	Check all exercises.
110	Constant addend and subtrahend should be used to check exercises.
111,112	At this time, let's not use calculator to check verbal problems.
113,114	Check all exercises.
115	Same suggestion as for pages 107 and 108.
116	Check all exercises.
117	Same as pages 111 and 112.

Houghton-Mifflin, Grade 2

Page	Suggestions
118	Check all exercises.
119-122	Use of calculator may get in the way of basic concept being taught.
123-124	Nature of pages suggests no calculator use.
125	No further suggestions.
126	Check all exercises.
127	Somewhat confusing format indicates calculator use may be unwise.
128	Check all exercises.
129,130	Check all exercises.
131	Same comment as for page 127.
132	Check exercises at top. Secret code should be self-checking.
133,134	Format precludes giving any checking suggestions.
135,137	Check all exercises.
136,138	OK to check exercises at top.
139,140	Format precludes giving any checking suggestion.
141	Check exercises.
142	No other suggestions.
143	Check exercises.
144	No other suggestions.
145	Constant addend feature here makes checking quite easy.
146	Check exercises.
147	No other suggestions.
148	Check exercises.
149,150	Constant addend can be used to check bottom of p. 149 and all of p. 150.
151	No further suggestions.
152	Check exercises.
153,154	Same basic suggestion as for pages 149, 150.
155,156	Nature of pages precludes use of calculator.
157-163	Do not bother with calculator to check answers.
164-170	All the intermediate steps on these pages that are designed to give some meaning to the algorithm tend to make the pages somewhat confusing and generally hard to check with a calculator.

Houghton-Mifflin, Grade 2

Page	Suggestions
164-170	However, the calculator could be used to verify the answer if only the first problem stimulus--e.g., 32 is put into the calculator and then the final answer is $\underline{+24}$ verified.
171	Check all exercises below the box.
172-180	Same basic suggestion as for pages 164-170; do not try to check any of the intermediate steps designed to teach meaning, but rather check the initial algorithm stimulus against the final answer.
181-182	Check all exercises.
183,184, 185	No further suggestions.
186	Use constant addend to check exercises at bottom of page.
187,188	No further suggestions.
189-192	Nature of pages precludes use of calculator.
193	Same type of suggestion as for pages 164-170.
194,195, 196	Check exercises except for those at top of page 196.
197,198	No further suggestions.
199-202	Same type of suggestion as for pages 164-170.
203-205	No further suggestions.
206	Since there are so many problems on this page, you may want to consider letting children do half of them with calculator first before doing them by paper-pencil methods.
207-216	Nature of pages precludes the use of calculators to check answers.
217-252	The pages in this chapter do not deal with addition/subtraction skills and so are not suitable for direct calculator use. This might be a good time to use calculator in supplementary work of drill and practice, especially with games.
253,254	Check all exercises.
255	No further suggestions.
256	Check all exercises.
257-259	Same suggestions as for pages 172-180.

Houghton-Mifflin, Grade 2

Page	Suggestions
260	Check all exercises.
261,262	No further suggestions.
263-265	Same suggestions as for pages 172-180.
266,267	Same suggestion as for page 206.
268	No further suggestions.
269,270	The repeated addend (of 10) can be used to good advantage here, especially with page 269.
271,272	No calculator use.
273-280	Check answers as appropriate, leaving out checks of all intermediate steps included to give meaning to algorithms.
281,282	No calculator use.
283	Check answers at bottom of page.
284-286	No calculator use.

Specific Calculator Suggestions

Houghton Mifflin Grade 3

The overall suggestions of using the calculator as part of an onging program of drill and practice, such as "flash card" use of in games will not be given for each page or chapter. It is hoped that you will use these suggestions whenever practical, as well as the suggestion to let the children engage in free exploration.

Page	Suggestions
61	Check answers to exercises 1-20.
62	Check answers to exercises 1-6 and 15-26. The make-up of some of those exercises require child to determine sum on left side of equation and then check whether response on right side agrees with that sum. Exercises 7-14 can be checked using the constant addend feature.
63	Check answers to exercises 1-18. Exercises 19-21 can be checked using the constant addend feature.
64	Check answers to exercises 1-21. Exercises 22-36 can be checked using the constant subtrahend.
65	Check answers to exercises 1-18.
66	Check answers, though calculator cannot tell student that he/she should have subtracted instead of adding, or vice versa.
67	Because of complicated layout of page, checking is not advised.
68,69	Check answers to exercises 1-24.
70	Check exercises 5-19.
71	No further suggestions.
72	Because of complicated layout of page, suggest only check exercises 1-6.
73	Check exercises 1-20.
74	Check exercises 2, 4, 6, 8, 10, 11-15.
75	Check exercises 1-19.
76,77	No calculator usage, except for some free exploration.
78,79	No calculator usage, except for some free exploration.
80	Complicated page layout precludes checking answers.

Houghton-Mifflin, Grade 3

Page	Suggestions
81	Check exercises 1-24.
82	Check exercises 9-19.
83	Check exercises 1-25.
84	No usage.
85	Check exercises 20-29.
86,87	Check answers to all exercises.
88	If children know that they must subtract, then they can check answers.
89	Check answers to exercises 1-35.
90	Check exercises 1-12 and 17-26. Exercises 13-16 can be checked using constant addend.
91	Check exercises 9-18.
92	Check all exercises.
93-124	Since this is geometry, no suggestions other than free exploration.
125-156	Throughout the entire chapter on multiplication and division, use of the constant for repeated counting can be used to good advantage in helping to develop the conceptual understanding in children of multiplication as repeated addition and division as repeated subtraction.
125	Check exercises by using constant addend-repeated counting.
126	Check all exercises.
127	Check exercises 1-18. Exercises 10-18 lend themselves to check using the constant factor.
128	Check all exercises. Might wish to begin using calculator as flash card for "2's" facts.
129	Check all exercises. Flash card for "2's."
130	Check exercises 12-20 using constant divisor.
131	Check exercises 1-24. Constant factor and constant divisor can be used.
132	Check all exercises.
133	Check exercises 1-19. Constant factor can be used to good advantage here.
134	Check all exercises. Flash card for "2's" and "3's."
135	No further suggestions.

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Page	Suggestions
136	Check all exercises.
137	Check exercises 1-19. Another good place for constant factor.
138,139	Check all exercises. Flash card can include "4's."
140	Check exercises 11-21 using constant factor.
141	Check exercises 1-20.
142	Check all exercises.
143	Check exercises 1-19 using constant factor.
144	Check exercises 12-35.
145,146 147	Flash card can include "5's."
148	Check exercises 1-12.
149	Check all exercises.
150-156	No calculator usage other than flash card or free exploration.
157-158	This chapter on fractions does not lend itself to checking answers with the calculator or in using calculator features to help develop conceptual understanding. Thus, no specific suggestions are given.
189	The secret code is self-checking. No calculator use.
190,191	Check all answers.
192,193	Repeated adding feature of calculator can be used to check addition on left side of each page. Ordinary checking for other problems on these pages.
194,195	The format of these pages together with a real mixing up of types of problems indicates that calculator usage might be of limited value.
196	Check exercises 7 to 41.
197	No calculator use.
198-201	Same basic comment as for pages 194, 195.
202-208	No calculator use.
209	Check all exercises.

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Page	Suggestions
210	There are some intermediate steps inserted here to try to give meaning to the algorithm. Do not use calculator to check the accuracy of these steps. However, final answer can be checked against the original problem stimulus.
211	Check all exercises.
212,213	Same suggestion as for page 210.
214-220	Nature of pages indicates no calculator usage.
221-225	Check all exercises.
226	Probably not worth bothering with calculator here.
227,228	Check all exercises.
229	No calculator use.
230-232	Check all exercises.
233	No calculator use.
234,235	Check all exercises.
236,237	No calculator use.
238,239	Check all exercises except #1 and 9 on page 238.
240-245	No calculator usage.
246,247	Check all exercises, except 1-9 on page 246.
248,249	Check exercises 5-14 on both pages.
250-253	No calculator usage.
254,255	Exercises 10-18 on both pages can be checked using the constant factor feature. Remember that the constant factor on the calculator is the first factor entered.
256,257	No calculator usage.
258,259	Work is relatively simple. Probably do just as well to ignore calculator checking on these pages.
260	Format of page makes calculator checking very difficult.
261	Check exercises 6-18.
262	Same comment as for page 260.
263,264	Check all exercises. For exercises 1-10 on p. 264, only check the final answer and not the intermediate steps.

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Page	Suggestions
265	Check all exercises. Note that exercises 1-12 can be checked by keying into the calculator the numerals and symbols, except the parentheses, exactly as they are given in the exercises. For example, (9 x 4) + 3 is checked by depressing the 9 x 4 + 3 = buttons in that order.
266, 267	Check all exercises, omitting intermediate steps on p. 266.
268-277	No calculator usage.
278,279	All work with multiples can be checked very nicely using the constant (or repeated) addend feature of the calculator.
280	No calculator usage.
281	Check exercises 1-30.
282-299	No calculator usage.
300-303	Check all exercises, skipping the intermediate multiplication steps on page 302.
304-316	No calculator usage.

Specific Calculator Suggestions

DMP Grade 2

Activity/Topic	Suggestions
All	Flash card practice with basic addition/subtraction facts is recommended at any time deemed appropriate by the teacher. Similarly, free exploration is always a calculator activity that a child can do at any time. These two suggestions will not be explicitly mentioned for each activity/topic listed.
Topic 28	No specific suggestions for this geometric topic.
29A,29B	No specific suggestions.
29C	Children can check the solutions to the sentences they write.
29D	Can check solutions on all pages except page 9.
29E	Can check solutions on all pages.
29F	Check solutions on page 19.
29G	Since a main point of this activity is the graph and its interpretation, you may want to permit the children to use the calculator to compute the sum of the numbers thrown on the dice.
29H-29K	Check solutions to problems on all pages except page 21.
Topic 30	Some of the work in this topic lends itself very nicely to the repeated counting idea, both with addition and subtraction. Although the teacher's guide does not specifically call for this underlying method, let's consider a way that a child can check whether or not his/her grouping was done correctly. It would require the child's ability to count by 1's to any reasonably sized number. Suppose it is 38. If the child were given 38 objects and told to group by 5, the correct response would be 7(5) + 3. Using the calculator to add

DMP, Grade 2

Activity/Topic	Suggestions
Topic 30	repeatedly, the child could add 5 seven times and then add the final 3 and the display would read 38. Another way also mirrors the way the child actually does the problem physically--i.e., repeatedly taking 5 objects away from the set until less than 5 objects remains. On the calculator, the child would do 38 - 5 - 5 - 5 - 5 - 5 - 5 - 5 until 3 is shown on the display. If he/she remembers that 5 was subtracted 7 times, then the grouping notation 7(5) + 3 appropriately shows what has happened, both with objects and on the calculator.
30A-30C	No specific suggestions since notation is not heavily stressed in these first activities.
30D	Part 2 lends itself very nicely to general suggestion made at the beginning of this topic.
30E	Pages 6-8 work nicely with general suggestion. Each of the four different notations should yield the same total number.
30F	This is a pretty difficult activity. No suggestions.
30G	General suggestion applies here except maybe not with the money pages.
30H	Check only page 17.
30I	The general suggestions works nicely with regrouping. The total number from the regrouped set notation should be the same as the total determined from the original grouping.
30J,30K	Probably just as well not to bother with calculator on these two.
Topic 31	No specific suggestions for this geometric topic. Occasional flash card work with those who finish early might be good.
Topic 32	In general, the calculator can be used to check the solution to any sentence, either written by child or as presented on various pages. Of course, the calculator cannot check the correctness of open sentence being written by the child.

DMP, Grade 2

Activity/Topic	Suggestions
32A	Since the emphasis of this activity is really sentence writing, no calculator suggestions are given.
32B	Again, sentence writing seems to be important. No suggestions.
32C	Check pages 8 & 9.
32D	Check solutions to sentences written.
32E	Probably best to not use calculators here.
32F	Much like activity 29G. Maybe use calculator, if needed, to play game.
32G	Check pages 15-17.
32H	Check pages 19-21.
32I-32K	May be just as well to let children validate work in ways other than with the calculator.
Topic 33	Throughout this topic, careful use of the repeated addition feature of the constant addend should help children's conceptual understanding of grouping and regrouping by 10's.
33A	No additional suggestions.
33B	In this and following activities, expanded notation can be demonstrated on calculator to give compact notation. Here's an example: suppose you have 3(10) + 7; the keying sequence and the resulting display are as follows.

	key	display
	0	0
	+	0
	1	1
	0	10
Pushing the "=" button 3 times corresponds to the 3 tens.	=	10
	=	20
	=	30
	+	30
	7	7
	=	37

Activity/Topic	Suggestions
33B	It looks like a lot, but it can go rather quickly once children get the feel for the sequence of key stroking. The compact notation on workbook pages 2-6 can be check in this fashion.
33C	Page 7 can be checked in same fashion as described above.
33D	If desired, pages 8-10 can be checked using same method.
33E	Check pages 13 and 14.
33F,33G	No specific suggestions.
33H	On any of the pages employing expanded notation, the conversion to compact notation can be checked using the method described above. The completed page 21 offers some very nice opportunities to look for patterns and check them with the repeated addition/subtraction feature of calculator. For example, any vertical column can be generated by taking the top (bottom) number and entering it in the calculator and then repeatedly adding (subtracting) 10. In a similar fashion, diagonals going from upper right to lower left contain numbers that differ by 9; going down, one constantly adds 9 and going up, one constantly subtracts 9. The other diagonals going from upper left to lower right work with the constand of 11.
33I	No specific suggestions.
Topic 34	No suggestions for this topic.
Topic 35	As with Topic 32, the calculator can be used to check solutions to sentences either written by or given to student, but is of no use in checking correctness of open sentences written.
35A	No specific suggestions.
35B	Check solutions to sentences on pages 6, 7, 8, and 10.
35C	Check page 12.
35D,35E	Check solutions to all pages.

DMP, Grade 2

Activity/Topic	Suggestions
35F	No specific suggestions.
35G	Check solutions to all pages.
35H	Check pages 32 and 33.
35I,35J	No specific suggestions.
Topic 36	No suggestions for this topic.
Topic 37	Many of the basic ideas suggested in the prologue to the specific suggestions for activities in Topic 30 are also appropriate here. In other words, once a child has partitioned a set of known size and has written the grouping notation for that partitioning, a check can be made by using repeated addition.
37A	Check pages 2 and 3 using method for Topic 30.
37B	No specific suggestions for this developmental activity.
37C	No specific suggestions.
37D	Check all pages.
37E	Check pages 9, 10, 11, and 14.
37F,37G, 37H	No suggestions for these activities dealing with fractions.
37I,37J, 37K	I don't think the calculator lends itself very well to these activities.
Topic 38	As with Topic 35, much of the emphasis here is on writing sentences, for which the calculator serves no real purpose as a checking device. It can be used to check solutions whenever the children are asked to solve sentences.
38A,38B	Since solving is not required, no calculator use.
38C,38D	Since a great deal of variability can arise from the measuring involved in these activities, no further calculator suggestions are given.
38E	Check solutions to sentences on pages 10, 11, and 12.
38F	No specific suggestions.
38G,38H	Check solutions to sentences on all pages.

Activity/Topic	Suggestions
38I	No specific suggestions.
38J	Check solution to page 16.
Topic 39	The measuring and fraction work of this topic do not lend themselves well to calculator work.
Topic 40	Since much of the work of this topic deals with computation, you should be able to find ample opportunity to use the calculators.
40A	No other specific suggestions.
40B	Assuming the children can decide whether to add or subtract, student booklet pages 5 & 6 can be checked with the calculator by having the children simply enter the compact numbers and the appropriate operation key.
40C	No other specific suggestions.
40D	In the various parts where computation is to be done in expanded notation, the work can be checked using calculators and compact notation.
40E	No specific suggestions.
40F	You may wish to consider allowing children to play game on student booklet page 12 with the calculator doing the computation.
40G	Check exercises on student booklet page 13.
40H	If Part 2 is done, calculations can be checked by machine.
40I	First game in Part 1 could be checked by calculator.
40J	Check exercises on all pages except page 18.
40K	Check exercises on pages 21-25.
40L	Check exercises on pages 29, 30, and 32.
Topic 41	No specific suggestions.
Topic 42	Check exercises on student booklet pages 4, 7 (use constant addend-repeated adding), and 14.

DMP, Grade 2

Activity/Topic	Suggestions
43A	No specific suggestions.
43B	Check exercises on Student Guide pages 2 and 3.
43C	Check exercises on student booklet page 9.
43D	No specific suggestions.
43E	Check exercises on student booklet pages 16-19.
43F	Check exercises on student booklet pages 20 and 22 and Student Guide pages 7 and 10.
43G	No specific suggestions.
43H	Check exercises on Student Guide pages 11-14.
43I,43J	No specific suggestions.
Topic 44	No specific suggestions for this geometric topic.

Specific Calculator Suggestions

DMP Grade 3

Activity/Topic	Suggestions
All	Flash card practice with basic addition/subtraction facts is recommended at any time deemed appropriate by the teacher. Similarly, free exploration is always a calculator activity that a child can do at any time. These two suggestions will not be explicitly mentioned for each activity/topic listed.
40A	No other specific suggestions.
40B	Assuming the children can decide whether to add or subtract, student booklet pages 5 & 6 can be checked with the calculator by having the children simply enter the compact numbers and the appropriate operation key.
40C	No other specific suggestions.
40D	In the various parts where computation is to be done in expanded notation, the work can be checked using calculators and compact notation.
40E	No specific suggestions.
40F	You may wish to consider allowing children to play game on student booklet page 12 with the calculator doing the computation.
40G	Check exercises on student booklet page 13.
40H	If Part 2 is done, calculations can be checked by machine.
40I	First game in Part 1 could be checked by calculator.
40J	Check exercises on all pages except page 18.
40K	Check exercises on pages 21-25.
40L	Check exercises on pages 29, 30, and 32.

DMP, Grade 3

Activity/Topic	Suggestions
Topic 41	No specific suggestions.
Topic 42	Check exercises on student booklet pages 4, 7 (use constant addend - repeated adding), and 14.
43A	No specific suggestions.
43B	Check exercises on Student Guide pages 2 and 3.
43C	Check exercises on student booklet page 9.
43D	No specific suggestions.
43E	Check exercises on student booklet pages 16-19.
43F	Check exercises on student booklet pages 20 and 22, and Student Guide pages 7 and 10.
43G	No specific suggestions.
43H	Check exercises on Student Guide pages 11-14.
43I,43J	No specific suggestions.
Topic 44	No specific suggestions for this geometric topic.
Topic 45	Throughout this topic, careful use of the repeated addition feature of the constant addend should help children's conceptual understanding of grouping and regrouping by 10's and 100's.
45A	No other specific suggestions other than here the use of the repeated counting-addition will show very nicely that 10 ten's indeed do make a hundred and that 10 hundreds will give a thousand.
45B	In this and following activities, expanded notation can be demonstrated on calculator to give compact notation. Here's an example: suppose you have 4(100) + 3(10) + 5; the keying sequence and the resulting display are as follows:

DMP, Grade 3

Activity/Topic	Suggestions	
45B	key	display
	0	0
	+	0
	1	1
	0	10
	0	100
	=	100
	=	200
	=	300
	=	400
	+	400
	1	1
	0	10
	=	410
	=	420
	=	430
	+	430
	5	5
	=	435
	It looks like a lot, but it really goes quickly once children get the feel for the sequence of key stroking.	
45C	Same basic suggestion as for 45B.	
45D	No other specific suggestions.	
45E	Can check exercises on student booklet pages 8 and 9 by using the basic suggestion of 45B.	
45F	No other specific suggestions.	
45G,45H, 45I	No other specific suggestions.	
45J	Check student booklet pages 15 and 16 using suggestion of 45B. Number patterns on booklet page 18 can be checked using repeated counting feature. The top of booklet page 20 and all of page 21 can be checked very nicely by repeated counting of 10's. The big danger is that they cannot count accurately.	

DMP, Grade 3

Activity/Topic	Suggestions
45K,45L	No other specific suggestions.
Topic 46	This measurement topic does not lend itself to specific calculator usage.
Topic 47	As the Overview to this topic suggests, repeated addition and repeated subtraction come into play rather heavily. Since the calculator has the repeated addend/subtrahend feature built in, it can be used to advantage here. For example, if a child wanted to know the total associated with 3(12), he/she could use the calculator in this way:

	key	display
	0	0
	+	0
	1	1
Pushing the "=" button	2	12
3 times corresponds to the "3" of 3(12).	=	12
	=	24
	=	36

Of course, the problem can also be solved by simply keystroking 3 X 12 = . The "X" symbol is not introduced until later in DMP but I see no real harm in using it here provided the children know what is going on. On the other hand, I do not advocate using the "÷" symbol for division as a substitute for repeated subtraction in partitioning problems since division will yield a decimal in cases where there is a remainder. I don't think the children are ready for that.

47A	Solutions to sentences on pages 2 and 3 can be checked.
47B	Solutions to sentences on pages 4, 5, and 6 can be checked.
47C	Check all pages.
47D	Check all pages.
47E	Check Booklet pages 13 and 14.
47F	Check all pages.

DMP, Grade 3

Activity/Topic	Suggestions
47G	Check Booklet page 24 and Guide page 11.
47H	Check all pages.
47I,47J	No suggestions since many of the pages have other ways of validating answers.
Topic 48	No suggestions for this geometric topic.
Topic 49	Except for Activities J and K that deal with fractions, the activities and pages of this topic are quite straightforward. Thus they lend themselves nicely to validation by the calculator whenever you wish to use that device. It seems pointless to go through each activity and say the same basic thing; so, it will be said once, "Check any or all pages."
Topic 50	This measurement topic does not lend itself to using the calculator with the exception of Activities G and H in which some addition and subtraction is done.
Topic 51	No specific suggestions for this measurement topic except for Activities A and H in which grouping and multiplication ideas are used. In those activities the work on the pages could be checked using the calculator.
Topic 52	No suggestions for this topic except for Activity 52H in which the Booklet pages can be checked with the calculator.

APPENDIX C

Data Tables

Table C2-1

Grade 2
Basic Addition Facts
S-F
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	46	.898	.168	22	.986	.032	24	.818	.200
	Control	44	.918	.162	21	.954	.055	23	.884	.215
F	Experimental	43	.705	.231	18	.855	.133	25	.597	.227
	Control	46	.720	.260	22	.779	.171	24	.666	.316
S-F	Experimental	41	.184	.165	17	.127	.134	24	.225	.176
	Control	44	.201	.216	21	.176	.184	23	.224	.243

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	3.168	1	3.168	84.90		.903	1	.903	33.62		2.369	1	2.369	53.06	
Groups	.006	1	.006	.16	.686	.023	1	.023	.87	.358	.000	1	.000	.00	.986
Within Groups	3.097	83	.037			.967	36	.027			2.009	45	.045		
Total	6.271					1.893	38				4.378				

243

Table C2-2

Grade 2
Basic Addition Facts
W-F
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
W	Experimental	48	.770	.237	23	.958	.070	25	.597	.201
	Control	43	.811	.204	21	.854	.183	22	.770	.218
F	Experimental	43	.705	.231	18	.855	.133	25	.597	.227
	Control	46	.720	.260	22	.779	.171	24	.666	.316
W-F	Experimental	43	.044	.163	18	.106	.119	25	-.000	.178
	Control	43	.109	.145	21	.086	.123	22	.132	.163

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	.506	1	.506	21.31		.352	1	.352	24.02		.179	1	.179	6.11	
Groups	.091	1	.091	3.85	.053	.004	1	.004	.26	.614	.204	1	.204	6.97	.011
Within Groups	1.998	84	.024			.542	37	.015			1.316	45	.029		
Total	2.596	85				.897	39				1.699	47			

Table C2-3

Grade 2
Basic Addition Facts
S-W
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	46	.898	.168	22	.986	.032	24	.818	.200
	Control	44	.918	.162	21	.954	.055	23	.884	.215
W	Experimental	48	.770	.237	23	.958	.070	25	.597	.201
	Control	43	.811	.204	21	.854	.183	22	.770	.218
S-W	Experimental	46	.128	.158	22	.025	.069	24	.223	.158
	Control	41	.110	.178	20	.105	.191	21	.114	.168

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	1.245	1	1.245	44.36		.167	1	.167	8.47		1.336	1	1.336	50.26	
Groups	.007	1	.007	.27	.607	.067	1	.067	3.39	.073	.133	1	.133	4.99	.031
Within Groups	2.385	85	.028			.791	40	.020			1.143	43	.027		
Total	3.638	87				1.026	42				2.611	45			

Table C2-4

Grade 2
Basic Subtraction Facts
S-F
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	46	.755	.263	22	.886	.231	24	.635	.234
	Control	44	.691	.289	21	.792	.213	23	.599	.321
F	Experimental	43	.310	.205	18	.363	.231	25	.271	.179
	Control	46	.391	.223	22	.456	.168	24	.331	.253
S-F	Experimental	41	.421	.247	17	.486	.236	24	.373	.249
	Control	44	.294	.217	21	.338	.194	23	.254	.233

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	10.732	1	10.732	199.30		6.247	1	6.247	137.12		4.658	1	4.658	80.04	
Groups	.339	1	.339	6.30	.014	.212	1	.212	4.65	.038	.165	1	.165	2.84	.099
Within Groups	4.469	83	.054			1.640	36	.046			2.619	45	.058		
Total	15.541	85				8.010	38				7.442	47			

Table C2-5

Grade 2
Basic Subtraction Facts
W-F
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
W	Experimental	48	.580	.235	23	.725	.223	25	.445	.153
	Control	43	.602	.292	21	.747	.234	22	.463	.278
F	Experimental	43	.310	.205	18	.363	.231	25	.271	.179
	Control	46	.391	.223	22	.456	.168	24	.331	.253
W-F	Experimental	43	.251	.218	18	.358	.238	25	.174	.174
	Control	43	.228	.209	21	.300	.188	22	.159	.206

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	4.935	1	4.935	108.27		4.172	1	4.172	93.72		1.310	1	1.310	36.57	
Groups	.011	1	.011	.25	.617	.033	1	.033	.73	.397	.003	1	.003	.07	.789
Within Groups	3.829	84	.046			1.647	37	.045			1.612	45	.036		
Total	8.776	86				5.851	39				2.925	47			

Table C2-6

Grade 2
Basic Subtraction Facts
S-W
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	46	.755	.263	22	.886	.231	24	.635	.234
	Control	44	.691	.289	21	.792	.213	23	.599	.321
W	Experimental	48	.580	.235	23	.725	.223	25	.445	.153
	Control	43	.602	.292	21	.747	.234	22	.463	.278
S-W	Experimental	46	.176	.201	22	.164	.193	24	.187	.212
	Control	41	.063	.223	20	.032	.190	21	.093	.233

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	1.316	1	1.316	29.37		.430	1	.430	11.73		.924	1	.924	17.30	
Groups	.276	1	.276	6.17	.015	.181	1	.181	4.95	.032	.100	1	.100	1.88	.178
Within Groups	3.808	85	.045			1.467	40	.037			2.297	43	.053		
Total	5.401	87				2.079	42				3.321	45			

Table C2-7

Grade 2
Solving Open Sentences
S-F

Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	46	.761	.172	22	.791	.163	24	.732	.179
	Control	44	.744	.242	21	.793	.160	23	.699	.295
F	Experimental	43	.448	.218	18	.590	.135	25	.346	.210
	Control	46	.526	.242	22	.558	.184	24	.496	.286
S-F	Experimental	41	.311	.188	17	.201	.146	24	.389	.178
	Control	44	.224	.153	21	.246	.150	23	.205	.156

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	Combined SS	df	MS	F	p	Falk SS	df	MS	F	p	Orchard Ridge SS	df	MS	F	p
Mean	6.025	1	6.025	206.24		1.940	1	1.940	88.27		4.197	1	4.197	149.56	
Groups	.159	1	.159	5.43	.022	.019	1	.019	.88	.355	.398	1	.398	14.20	.0005
Within Groups	2.425	83	.029			.791	36	.022			1.263	45	.028		
Total	8.608	85				2.750	38				5.858	47			

Table C2-8

Grade 2
Solving Open Sentences
W-F

Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
W	Experimental	48	.680	.220	23	.822	.112	25	.550	.216
	Control	43	.696	.219	21	.756	.140	22	.638	.267
F	Experimental	43	.448	.218	18	.590	.135	25	.346	.210
	Control	46	.526	.242	22	.558	.184	24	.496	.286
W-F	Experimental	43	.208	.122	18	.215	.156	25	.203	.093
	Control	43	.188	.181	21	.201	.195	22	.176	.169

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	3.380	1	3.380	142.41		1.676	1	1.676	52.87		1.709	1	1.709	94.67	
Groups	.009	1	.009	.38	.542	.002	1	.002	.07	.799	.009	1	.009	.49	.489
Within Groups	1.994	84	.024			1.173	37				.812	45	.018		
Total	5.382	86				2.851	39				2.530	47			

Table C2-9

Grade 2
Solving Open Sentences
S-W

Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	46	.761	.172	22	.791	.163	24	.732	.179
	Control	44	.744	.242	21	.793	.160	23	.699	.295
W	Experimental	48	.680	.220	23	.822	.112	25	.550	.216
	Control	43	.696	.219	21	.756	.140	22	.638	.267
S-W	Experimental	46	.087	.180	22	-.026	.131	24	.191	.155
	Control	41	.024	.142	20	.035	.125	21	.014	.159

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	Combined SS	df	MS	F	p	Falk SS	df	MS	F	p	Orchard Ridge SS	df	MS	F	p
Mean	.287	1	.287	10.80		.000	1	.000	.02		.528	1	.528	21.50	
Groups	.085	1	.085	3.18	.078	.040	1	.040	2.44	.126	.350	1	.350	14.26	.0005
Within Groups	2.262	85	.027			.659	40	.016			1.056	43	.025		
Total	2.634	87				.699	42				1.935	45			

Table C2-10

Grade 2
Two-digit Addition
S-F

Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	46	.739	.284	22	.921	.142	24	.573	.281
	Control	44	.688	.374	21	.833	.228	23	.554	.433
F	Experimental	43	.343	.291	18	.486	.234	25	.240	.293
	Control	46	.321	.340	22	.456	.285	24	.198	.346
S-F	Experimental	41	.366	.302	17	.427	.262	24	.323	.325
	Control	44	.370	.334	21	.393	.291	23	.348	.375

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	Combined SS	df	MS	F	p	Falk SS	df	MS	F	p	Orchard Ridge SS	df	MS	F	p
Mean	11.489	1	11.489	112.87		6.322	1	6.322	81.52		5.278	1	5.278	42.97	
Groups	.000	1	.000	.00	.960	.011	1	.011	.14	.714	.007	1	.007	.06	.809
Within Groups	8.448	83	.102			2.792	36	.078			5.528	45	.123		
Total	19.937	85				9.125	38				10.812	47			

Table C2-11

Grade 2
Two-digit Addition
W-F

Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
W	Experimental	48	.547	.395	23	.848	.235	25	.270	.297
	Control	43	.517	.351	21	.607	.257	22	.432	.410
F	Experimental	43	.343	.291	18	.486	.234	25	.240	.293
	Control	46	.321	.340	22	.456	.285	24	.198	.346
W-F	Experimental	43	.163	.298	18	.347	.273	25	.030	.243
	Control	43	.215	.259	21	.167	.266	22	.262	.250

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	Combined SS	df	MS	F	p	Falk SS	df	MS	F	p	Orchard Ridge SS	df	MS	F	p
Mean	3.070	1	3.070	39.33		2.438	1	2.438	33.60		.899	1	.899	14.85	
Groups	.059	1	.059	.75	.388	.316	1	.316	4.36	.044	.626	1	.626	10.35	.002
Within Groups	6.558	84	.078			2.684	37	.073			2.725	45	.061		
Total	9.688	86				5.438	39				4.250	47			

253

Table C2-12

Grade 2
Two-digit Addition
S-W

Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	46	.739	.284	22	.921	.142	24	.573	.281
	Control	44	.688	.374	21	.833	.228	23	.554	.433
W	Experimental	48	.547	.395	23	.848	.235	25	.270	.297
	Control	43	.517	.351	21	.607	.257	22	.432	.410
S-W	Experimental	46	.190	.299	22	.080	.236	24	.292	.319
	Control	41	.159	.315	20	.238	.309	21	.083	.310

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	2.673	1	2.673	28.43		1.006	1	1.006	13.49		1.701	1	1.701	17.21	
Groups	.022	1	.022	.23	.632	.261	1	.261	3.51	.069	.486	1	.486	4.92	.032
Within Groups	7.993	85	.094			2.983	40	.075			4.250	43	.099		
Total	10.688	87				4.250	42				6.438	45			

Table C2-13

Grade 2
Two-digit Subtraction
S-F

Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	46	.625	.328	22	.829	.260	24	.438	.268
	Control	44	.398	.351	21	.595	.279	23	.217	.314
F	Experimental	43	.151	.212	18	.333	.210	25	.020	.070
	Control	46	.185	.238	22	.296	.227	24	.083	.204
S-F	Experimental	41	.457	.256	17	.515	.257	24	.417	.252
	Control	44	.216	.283	21	.310	.284	23	.130	.260

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	9.389	1	9.389	128.56		6.120	1	6.120	82.46		3.596	1	3.596	55.00	
Groups	1.237	1	1.237	16.94	.0001	.396	1	.396	5.33	.027	.962	1	.962	14.72	.0004
Within Groups	6.062	83	.073			2.672	36	.074			2.942	45	.065		
Total	16.688	85				9.188	38				7.500	47			

255

Table C2-14

Grade 2
Two-digit Subtraction
W-F
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
W	Experimental	48	.323	.268	23	.500	.107	25	.160	.269
	Control	43	.256	.264	21	.393	.232	22	.125	.228
F	Experimental	43	.151	.212	18	.333	.210	25	.020	.070
	Control	46	.185	.238	22	.296	.227	24	.083	.204
W-F	Experimental	43	.151	.226	18	.167	.210	25	.140	.240
	Control	43	.087	.237	21	.107	.291	22	.068	.176

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	1.222	1	1.222	22.79		.707	1	.707	10.69		.532	1	.532	11.78	
Groups	.088	1	.088	1.64	.204	.034	1	.034	.52	.476	.060	1	.060	1.34	.254
Within Groups	4.503	84	.054			2.446	37	.066			2.033	45	.045		
Total	5.813	86				3.188	39				2.625	47			

Table C2-15

Grade 2
Two-digit Subtraction
S-W

Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	46	.625	.328	22	.829	.260	24	.438	.268
	Control	44	.398	.351	21	.595	.279	23	.217	.314
W	Experimental	48	.323	.268	23	.500	.107	25	.160	.269
	Control	43	.256	.264	21	.393	.232	22	.125	.228
S-W	Experimental	46	.299	.282	22	.330	.282	24	.271	.285
	Control	41	.116	.302	20	.188	.352	21	.048	.232

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	Combined SS	df	MS	F	p	Falk SS	df	MS	F	p	Orchard Ridge SS	df	MS	F	p
Mean	3.934	1	3.934	46.35		2.881	1	2.881	28.58		1.250	1	1.250	18.27	
Groups	.726	1	.726	8.56	.004	.211	1	.211	2.10	.155	.558	1	.558	8.16	.007
Within Groups	7.215	85	.085			4.033	40	.101			2.942	43	.068		
Total	11.875	87				7.125	42				4.750	45			

257

Table C2-16

Grade 2
Three-digit Addition
S-W
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	48	.724	.274	23	.924	.140	25	.540	.236
	Control	42	.583	.361	21	.738	.256	21	.429	.388
W	Experimental	47	.457	.377	22	.716	.259	25	.230	.314
	Control	40	.469	.321	21	.476	.222	19	.461	.411
S-W	Experimental	47	.266	.252	22	.216	.235	25	.310	.263
	Control	37	.108	.299	20	.263	.286	17	-.074	.193

Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	3.241	1	3.241	43.44		2.381	1	2.381	35.00		1.006	1	1.006	17.84	
Groups	.516	1	.516	6.91	.010	.023	1	.023	.33	.566	1.489	1	1.489	26.40	.000
Within Groups	6.118	82	.075			2.721	40	.068			2.256	40	.056		
Total	9.875	84				5.125	42				4.750	42			

Table C2-17

Grade 2
Three-digit Subtraction
S-W
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	48	.573	.282	23	.717	.285	25	.440	.208
	Control	42	.345	.307	21	.476	.249	21	.214	.309
W	Experimental	47	.255	.230	22	.421	.142	25	.110	.192
	Control	40	.344	.264	21	.429	.161	19	.250	.323
S-W	Experimental	47	.324	.280	20	.318	.269	25	.330	.295
	Control	37	-.020	.285	20	.050	.299	17	-.103	.251

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	Combined SS	df	MS	F	p	Falk SS	df	MS	F	p	Orchard Ridge SS	df	MS	F	p
Mean	2.503	1	2.503	31.40		1.524	1	1.524	18.91		1.006	1	1.006	12.99	
Groups	2.460	1	2.460	30.86	.000	.753	1	.753	9.35	.004	1.897	1	1.897	24.49	.000
Within Groups	6.537	82	.080			3.223	40	.081			3.098	40	.077		
Total	11.500	84				5.500	42				6.000	42			

Table C2-18

Grade 2
Place Value/Tens
S-W

Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	48	.791	.254	23	.844	.189	25	.743	.298
	Control	42	.766	.325	21	.865	.207	21	.666	.391
W	Experimental	47	.592	.288	22	.685	.236	25	.510	.308
	Control	40	.581	.323	21	.674	.271	19	.478	.351
S-W	Experimental	47	.195	.233	22	.152	.178	25	.233	.271
	Control	37	.187	.231	20	.200	.209	17	.172	.261

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	3.080	1	3.080	57.04		1.281	1	1.281	34.41		1.823	1	1.823	25.56	
Groups	.001	1	.001	.02	.876	.025	1	.025	.66	.421	.038	1	.038	.54	.468
Within Groups	4.428	82	.054			1.489	40	.037			2.854	40	.071		
Total	7.509	84				2.793	42				4.716	42			

Table C2-19

Grade 2
Ordering Two-digit Numbers
S-W
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	48	.937	.205	23	.942	.211	25	.933	.042
	Control	42	.877	.297	21	.952	.094	21	.802	.400
W	Experimental	47	.840	.293	22	.788	.357	25	.886	.219
	Control	40	.512	.482	21	.563	.476	19	.456	.496
S-W	Experimental	47	.096	.299	22	.152	.304	25	.047	.291
	Control	37	.410	.490	20	.408	.485	17	.412	.511

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	4.606	1	4.606	29.64		3.149	1	3.149	14.06		1.589	1	1.589	10.25	
Groups	2.042	1	2.042	13.14	.0005	.691	1	.691	4.31	.044	1.348	1	1.348	8.69	.005
Within Groups	12.742	82	.155			6.410	40	.160			6.203	40	.155		
Total	19.390	84				10.250	42				9.140	42			

261

Table C2-20

Grade 2
Basic Multiplication Facts
S-W
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	48	.321	.241	23	.373	.234	25	.273	.242
	Control	42	.287	.267	21	.258	.248	21	.317	.288
W	Experimental	47	.216	.208	22	.223	.179	25	.210	.233
	Control	40	.179	.238	21	.131	.176	19	.232	.287
S-W	Experimental	47	.112	.170	22	.167	.184	25	.063	.143
	Control	37	.079	.186	20	.117	.182	17	.034	.187

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	.792	1	.792	25.26		.856	1	.856	25.59		.111	1	.111	4.26	
Groups	.022	1	.022	.71	.401	.026	1	.026	.78	.381	.008	1	.008	.33	.572
Within Groups	2.572	82	.031			1.338	40	.033			1.047	40	.026		
Total	3.387	84				2.220	42				1.167	42			

Table C3-1

Grade 3
Basic Addition Facts
S-F

Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	44	.920	.168	21	.928	.219	23	.913	.106
	Control	38	.976	.055	25	.984	.038	13	.961	.077
F	Experimental	42	.970	.059	21	.983	.037	21	.957	.073
	Control	44	.953	.094	22	.977	.040	22	.929	.124
S-F	Experimental	42	-.044	.177	21	-.055	.227	21	-.034	.110
	Control	34	.033	.093	21	.012	.055	13	.066	.130

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	.007	1	.007	.35	.558	.019	1	.019	.70	.408	.001	1	.001	.05	.830
Groups	.110	1	.110	5.22	.025	.047	1	.047	1.72	.198	.079	1	.079	5.66	.024
Within Groups	1.565	74	.021			1.092	40	.027			.446	32	.014		
Total	1.683	76				1.158	42				.526	34			

Table C3-2

Grade 3
Basic Addition Facts
W-F
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
W	Experimental	41	.968	.079	20	.980	.053	21	.957	.098
	Control	49	.973	.067	25	.984	.038	24	.962	.088
F	Experimental	42	.970	.059	21	.983	.037	21	.957	.073
	Control	44	.953	.094	22	.977	.040	22	.929	.124
W-F	Experimental	39	.001	.095	20	-.002	.066	19	.005	.119
	Control	41	.017	.060	21	.007	.056	20	.028	.064

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	.007	1	.007	1.16	.284	.000	1	.000	.07	.790	.011	1	.011	1.22	.276
Groups	.005	1	.005	.80	.373	.001	1	.001	.26	.616	.005	1	.005	.53	.470
Within Groups	.485	78	.006			.146	39	.004			.334	37	.009		
Total	.498	80				.147	41				.350	39			

Table C3-3

Grade 3
Basic Addition Facts
S-W
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	44	.920	.168	21	.928	.219	23	.913	.106
	Control	38	.976	.055	25	.984	.038	13	.961	.077
W	Experimental	41	.968	.079	20	.980	.053	21	.957	.098
	Control	49	.973	.067	25	.984	.038	24	.962	.088
S-W	Experimental	41	-.049	.186	20	-.055	.233	21	-.043	.133
	Control	35	.003	.062	24	.000	.052	11	.009	.083

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	Combined SS	df	MS	F	p	Falk SS	df	MS	F	p	Orchard Ridge SS	df	MS	F	p
Mean	.048	1	.048	2.34	.131	.028	1	.028	1.06	.309	.020	1	.020	1.44	.239
Groups	.051	1	.051	2.47	.120	.033	1	.033	1.27	.266	.020	1	.020	1.40	.246
Within Groups	1.517	74	.021			1.092	42	.026			.423	30	.014		
Total	1.616	76				1.152	44				.463	32			

Table C3-4

Grade 3
Basic Subtraction Facts
S-F

Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	44	.970	.111	21	.981	.052	23	.961	.147
	Control	38	.918	.158	25	.940	.142	13	.877	.183
F	Experimental	42	.802	.241	21	.847	.216	21	.757	.261
	Control	44	.778	.224	22	.802	.192	22	.754	.254
S-F	Experimental	42	.170	.222	21	.134	.189	21	.205	.250
	Control	34	.130	.175	21	.119	.181	13	.146	.172

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	1.747	1	1.747	42.75	.000	.671	1	.671	19.65	.000	1.136	1	1.136	22.74	
Groups	.030	1	.030	.73	.395	.002	1	.002	.06	.802	.028	1	.028	.56	.460
Within Groups	3.024	74	.041			1.366	40	.034			1.598	32	.050		
Total	4.802	76				2.039	42				2.762	34			

Table C3-5

Grade 3
Basic Subtraction Facts
W-F
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
W	Experimental	41	.934	.181	20	.955	.095	21	.914	.237
	Control	49	.898	.194	25	.916	.160	24	.879	.227
F	Experimental	42	.802	.241	21	.847	.216	21	.757	.261
	Control	44	.778	.224	22	.802	.192	22	.754	.254
W-F	Experimental	39	.140	.193	20	.115	.208	19	.166	.177
	Control	41	.116	.224	21	.100	.186	20	.133	.263

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	1.305	1	1.305	29.75	.000	.473	1	.473	12.19	.001	.866	1	.866	17.13	.000
Groups	.012	1	.012	.26	.609	.002	1	.002	.06	.809	.011	1	.011	.22	.643
Within Groups	3.422	78	.044			1.515	39	.039			1.871	37	.051		
Total	4.739	80				1.990	41				2.749	39			

Table C3-6

Grade 3
Basic Subtraction Facts
S-W
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	44	.970	.111	21	.981	.052	23	.961	.147
	Control	38	.918	.158	25	.940	.142	13	.877	.183
W	Experimental	41	.934	.181	20	.955	.095	21	.914	.237
	Control	49	.898	.194	25	.916	.160	24	.879	.227
S-W	Experimental	41	.034	.167	20	.025	.064	21	.043	.227
	Control	35	.046	.146	24	.042	.078	11	.055	.243

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	.119	1	.119	4.78	.032	.052	1	.052	9.95	.003	.070	1	.070	1.30	.263
Groups	.003	1	.003	.10	.750	.003	1	.003	.58	.449	.001	1	.001	.02	.893
Within Groups	1.843	74	.025			.218	42	.005			1.621	30	.054		
Total	1.964	76				.272	44				1.692	32			

Table C3-7

Grade 3
Solving Open Sentences
S-F
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	44	.756	.165	21	.730	.114	23	.780	.201
	Control	38	.719	.195	25	.731	.176	13	.697	.232
F	Experimental	42	.692	.179	21	.690	.148	21	.695	.209
	Control	44	.678	.177	22	.730	.151	22	.627	.189
S-F	Experimental	42	.067	.131	21	.040	.151	21	.093	.103
	Control	34	.011	.123	21	-.020	.105	13	.061	.137

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	.132	1	.132	8.17		.004	1	.004	.25		.223	1	.223	16.27	
Groups	.058	1	.058	3.60	.062	.037	1	.037	2.21	.145	.008	1	.008	.63	.435
Within Groups	1.197	74	.016			.677	40	.017			.438	32	.014		
Total	1.388	76				.718	42				.670	34			

269

Table C3-8

Grade 3
Solving Open Sentences
W-F

Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
W	Experimental	41	.707	.204	20	.716	.183	21	.698	.227
	Control	49	.717	.214	25	.711	.198	24	.724	.234
F	Experimental	42	.692	.179	21	.690	.148	21	.695	.209
	Control	44	.678	.177	22	.730	.151	22	.627	.189
W-F	Experimental	39	.016	.096	20	.028	.102	19	.002	.091
	Control	41	.017	.185	21	-.046	.118	20	.083	.220

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	.021	1	.021	.96		.004	1	.004	.33		.074	1	.074	2.57	
Groups	.000	1	.000	.00	.978	.057	1	.057	4.71	.036	.063	1	.063	2.17	.149
Within Groups	1.722	78	.022			.474	39	.012			1.071	37	.029		
Total	1.743	80				.535	41				1.208	39			

Table C3-9

Grade 3
Solving Open Sentences
S-W
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	44	.756	.165	21	.730	.114	23	.780	.201
	Control	38	.719	.195	25	.731	.176	13	.697	.232
W	Experimental	41	.707	.204	20	.716	.183	21	.698	.227
	Control	49	.717	.214	25	.711	.198	24	.724	.234
S-W	Experimental	41	.050	.139	20	.014	.170	21	.085	.094
	Control	35	.022	.150	24	.021	.136	11	.025	.185

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	.106	1	.106	5.08		.014	1	.014	.60		.132	1	.132	7.66	
Groups	.015	1	.015	.71	.402	.001	1	.001	.02	.882	.026	1	.026	1.48	.233
Within Groups	1.543	74	.021			.973	42	.023			.519	30	.017		
Total	1.665	76				.988	44				.677	32			

271

Table C3-10

Grade 3
Two-digit Addition
S-F
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	44	.955	.111	21	.952	.101	23	.957	.123
	Control	38	.921	.194	25	.930	.184	13	.904	.217
F	Experimental	42	.768	.237	21	.881	.203	21	.655	.216
	Control	44	.739	.341	22	.921	.195	22	.557	.361
S-F	Experimental	42	.185	.259	21	.071	.226	21	.298	.245
	Control	34	.110	.355	21	.000	.306	13	.289	.366

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	Combined SS	df	MS	F	p	Falk SS	df	MS	F	p	Orchard Ridge SS	df	MS	F	p
Mean	1.740	1	1.740	18.65		.054	1	.054	.74	.395	2.941	1	2.941	33.52	
Groups	.104	1	.104	1.11	.296	.054	1	.054	.74	.395	.001	1	.001	.01	.931
Within Groups	6.906	74	.093			2.893	40	.072			2.808	32	.088		
Total	8.750	76				3.000	42				5.750	34			

Table C3-11

Grade 3
Two-digit Addition
W-F
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
W	Experimental	41	.921	.233	20	.950	.131	21	.893	.302
	Control	49	.934	.151	25	.940	.131	24	.927	.173
F	Experimental	42	.768	.237	21	.881	.203	21	.655	.216
	Control	44	.739	.341	22	.921	.195	22	.557	.361
W-F	Experimental	39	.141	.297	20	.075	.258	19	.211	.326
	Control	41	.177	.350	21	.012	.201	20	.350	.392

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	2.032	1	2.032	19.20		.075	1	.075	1.41	.243	3.103	1	3.103	23.75	
Groups	.026	1	.026	.24	.624	.041	1	.041	.77	.386	.190	1	.190	1.45	.236
Within Groups	8.255	78	.106			2.072	39	.053			4.833	37	.131		
Total	10.313	80				2.188	41				8.125	39			

Table C3-12

Grade 3
Two-digit Addition
S-W
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	44	.955	.111	21	.952	.101	23	.957	.123
	Control	38	.921	.194	25	.930	.184	13	.904	.217
W	Experimental	41	.921	.233	20	.950	.131	21	.893	.302
	Control	49	.934	.151	25	.940	.131	24	.927	.173
S-W	Experimental	41	.030	.263	20	.000	.141	21	.060	.344
	Control	35	.014	.271	24	.010	.227	11	.023	.362

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	.040	1	.040	.57	.454	.001	1	.001	.04	.846	.070	1	.070	.57	.454
Groups	.005	1	.005	.07	.793	.001	1	.001	.03	.859	.010	1	.010	.08	.779
Within Groups	5.267	74	.071			1.560	42	.037			3.670	30	.122		
Total	5.313	76				1.563	44				3.750	32			

Table C3-13

Grade 3
Two-digit Subtraction
S-F
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	44	.932	.146	21	.964	.120	23	.902	.164
	Control	38	.855	.264	25	.890	.240	13	.789	.304
F	Experimental	42	.458	.174	21	.500	.137	21	.417	.195
	Control	44	.443	.263	22	.591	.212	22	.296	.227
S-F	Experimental	42	.476	.205	21	.464	.182	21	.488	.230
	Control	34	.368	.349	21	.310	.284	13	.462	.431

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	13.898	1	13.898	178.69		6.287	1	6.287	110.60		7.767	1	7.767	75.53	
Groups	.221	1	.221	2.85	.096	.251	1	.251	4.42	.042	.006	1	.006	.06	.816
Within Groups	5.756	74	.078			2.274	40	.057			3.290	32	.103		
Total	19.875	76				8.813	42				11.063	34			

Table C3-14

Grade 3
Two-digit Subtraction
W-F

Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
W	Experimental	41	.848	.267	20	.863	.250	21	.833	.289
	Control	49	.862	.205	25	.780	.232	24	.948	.127
F	Experimental	42	.458	.174	21	.500	.137	21	.417	.199
	Control	44	.443	.263	22	.591	.212	22	.296	.227
W-F	Experimental	39	.404	.241	20	.363	.172	19	.447	.296
	Control	41	.384	.336	21	.143	.203	20	.638	.250

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	12.403	1	12.403	144.09		2.563	1	2.563	72.38		11.579	1	11.579	155.40	
Groups	.008	1	.008	.09	.765	.494	1	.494	13.96	.001	.352	1	.352	4.73	.036
Within Groups	6.714	78	.086			1.381	39	.035			2.757	37	.075		
Total	19.125	80				4.438	41				14.688	39			

Table C3-15

Grade 3
Two-digit Subtraction
S-W
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	44	.932	.146	21	.964	.120	23	.902	.164
	Control	38	.855	.264	25	.890	.240	13	.789	.304
W	Experimental	41	.848	.267	20	.863	.250	21	.833	.289
	Control	49	.862	.205	25	.780	.232	24	.948	.127
S-W	Experimental	41	.079	.287	20	.100	.286	21	.060	.295
	Control	35	.014	.303	24	.115	.255	11	-.205	.292

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	.185	1	.185	2.13	.149	.513	1	.513	7.07	.011	.031	1	.031	.36	.552
Groups	.080	1	.080	.92	.341	.002	1	.002	.03	.859	.503	1	.503	5.83	.022
Within Groups	6.423	74	.087			3.047	42	.073			2.590	30	.086		
Total	6.688	76				3.563	44				3.125	32			

277

Table C3-16

Grade 3
Three-digit Addition
S-F
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	44	.892	.174	21	.941	.156	23	.848	.181
	Control	38	.842	.275	25	.860	.315	13	.808	.181
F	Experimental	42	.702	.216	21	.833	.183	21	.571	.161
	Control	44	.659	.350	22	.841	.197	22	.477	.377
S-F	Experimental	42	.191	.205	21	.107	.187	21	.274	.192
	Control	34	.103	.399	21	-.012	.422	13	.289	.286

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	1.740	1	1.740	18.42		.095	1	.095	.90	.350	2.654	1	2.654	49.42	
Groups	.144	1	.144	1.52	.221	.149	1	.149	1.40	.244	.002	1	.002	.03	.859
Within Groups	6.991	74	.094			4.256	40	.106			1.719	32	.054		
Total	8.875	76				4.500	42				4.375	34			

Table C3-17

Grade 3
Three-digit Addition
W-F
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
W	Experimental	41	.921	.227	20	.975	.077	21	.869	.302
	Control	49	.939	.120	25	.930	.135	24	.948	.104
F	Experimental	42	.702	.216	21	.833	.183	21	.571	.161
	Control	44	.659	.350	22	.841	.197	22	.477	.377
W-F	Experimental	39	.218	.288	20	.150	.205	19	.290	.346
	Control	41	.262	.344	21	.083	.199	20	.450	.368

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	4.632	1	4.632	45.78		.550	1	.550	13.48	.001	5.391	1	5.391	42.15	
Groups	.039	1	.039	.39	.536	.046	1	.046	1.12	.297	.251	1	.251	1.96	.170
Within Groups	7.891	78	.101			1.592	39	.041			4.733	37	.128		
Total	12.563	80				2.188	41				10.375	39			

279

Table C3-18

Grade 3
Three-digit Addition
S-W
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	44	.892	.174	21	.941	.156	23	.848	.181
	Control	38	.842	.275	25	.860	.315	13	.808	.181
W	Experimental	41	.921	.227	20	.975	.077	21	.869	.302
	Control	49	.939	.120	25	.930	.135	24	.948	.104
S-W	Experimental	41	-.024	.229	20	-.038	.186	21	-.012	.268
	Control	35	-.079	.248	24	-.052	.276	11	-.136	.172

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	Combined SS	df	MS	F	p	Falk SS	df	MS	F	p	Orchard Ridge SS	df	MS	F	p
Mean	.185	1	.185	3.26	.075	.091	1	.091	1.59	.215	.096	1	.096	1.66	.208
Groups	.055	1	.055	.98	.326	.002	1	.002	.04	.842	.112	1	.112	1.94	.174
Within Groups	4.197	74	.057			2.407	42	.057			1.730	30	.058		
Total	4.438	76				2.500	44				1.938	32			

Table C3-19

Grade 3
Three-digit Subtraction
S-F
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	44	.881	.191	21	.881	.187	23	.880	.198
	Control	38	.737	.318	25	.760	.302	13	.692	.356
F	Experimental	42	.310	.240	21	.452	.150	21	.167	.228
	Control	44	.375	.288	22	.523	.266	22	.227	.230
S-F	Experimental	42	.566	.303	21	.429	.226	21	.702	.312
	Control	34	.294	.424	21	.191	.362	13	.462	.477

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	14.988	1	14.988	114.44		4.024	1	4.024	44.33		12.664	1	12.664	86.53	
Groups	1.384	1	1.384	10.56	.002	.595	1	.595	6.56	.014	.466	1	.466	3.18	.084
Within Groups	9.691	74	.131			3.631	40	.091			4.683	32	.146		
Total	26.063	76				8.250	42				17.813	34			

Table C3-20

Grade 3
Three-digit Subtraction
W-F

Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
W	Experimental	41	.701	.346	20	.725	.323	21	.679	.372
	Control	49	.802	.238	25	.700	.270	24	.896	.146
F	Experimental	42	.310	.240	21	.452	.150	21	.167	.228
	Control	44	.375	.288	22	.523	.266	22	.227	.230
W-F	Experimental	39	.391	.417	20	.275	.291	19	.513	.496
	Control	41	.415	.382	21	.167	.310	20	.675	.258

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	13.001	1	13.001	81.61		1.976	1	1.976	21.83		13.861	1	13.861	90.02	
Groups	.011	1	.011	.07	.792	.120	1	.120	1.33	.256	.255	1	.255	1.66	.206
Within Groups	12.426	78	.159			3.529	39	.090			5.697	37	.154		
Total	25.438	80				5.625	41				19.813	39			

Table C3-21

Grade 3
Three-digit Subtraction
S-W

Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	44	.881	.191	21	.881	.187	23	.880	.198
	Control	38	.737	.318	25	.760	.302	13	.692	.356
W	Experimental	41	.701	.346	20	.725	.323	21	.679	.372
	Control	49	.802	.238	25	.700	.270	24	.896	.146
S-W	Experimental	41	.171	.308	20	.150	.318	21	.190	.305
	Control	35	-.014	.374	24	.083	.319	11	-.227	.410

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	.556	1	.556	4.81	.031	.568	1	.568	5.60	.023	.070	1	.070	.60	.447
Groups	.646	1	.646	5.60	.021	.048	1	.048	.48	.493	1.260	1	1.260	10.66	.003
Within Groups	8.548	74	.116			4.258	42	.101			3.545	30	.118		
Total	9.750	76				4.875	44				4.875	32			

Table C3-22

Grade 3
Place Value
S-F

Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	44	.855	.197	21	.827	.197	23	.880	.199
	Control	38	.661	.338	25	.692	.316	13	.601	.382
F	Experimental	41	.559	.299	20	.592	.263	21	.528	.334
	Control	52	.531	.340	26	.703	.299	26	.359	.291
S-F	Experimental	41	.287	.245	20	.230	.208	21	.341	.270
	Control	38	.054	.224	25	-.019	.167	13	.194	.258

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	2.413	1	2.413	43.61		.378	1	.378	10.92		2.757	1	2.757	39.06	
Groups	1.072	1	1.072	19.37	.000	.689	1	.689	19.92	.000	.174	1	.174	2.46	.126
Within Groups	4.260	77	.055			1.488	43	.035			2.259	32	.071		
Total	7.745	79				2.555	45				5.190	34			

Table C3-23

Grade 3
Place Value
W-F

Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
W	Experimental	41	.632	.247	20	.537	.204	21	.723	.255
	Control	49	.576	.256	25	.632	.264	24	.518	.240
F	Experimental	41	.559	.299	20	.592	.263	21	.528	.334
	Control	52	.531	.340	26	.703	.299	26	.359	.291
W-F	Experimental	39	.082	.238	20	-.054	.191	19	.226	.197
	Control	49	.048	.211	25	-.069	.169	24	.169	.182

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	.348	1	.348	6.97		.176	1	.176	5.49		1.621	1	1.621	45.69	
Groups	.026	1	.026	.53	.470	.002	1	.002	.07	.787	.035	1	.035	.98	.328
Within Groups	4.293	86	.050			1.379	43	.032			1.454	41	.035		
Total	4.667	88				1.557	45				3.110	43			

285

Table C3-24

Grade 3
Place Value
S-W

Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	44	.855	.197	21	.827	.197	23	.880	.199
	Control	38	.661	.338	25	.692	.316	13	.601	.382
W	Experimental	41	.632	.247	20	.537	.204	21	.723	.255
	Control	49	.576	.256	25	.632	.264	24	.518	.240
S-W	Experimental	41	.220	.201	20	.284	.201	21	.158	.184
	Control	35	.084	.177	24	.076	.154	11	.102	.226

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	1.876	1	1.876	51.93		1.279	1	1.279	40.77		.616	1	.616	15.57	
Groups	.347	1	.347	9.62	.003	.476	1	.476	15.17	.000	.022	1	.022	.56	.459
Within Groups	2.674	74	.036			1.317	42	.031			1.187	30	.040		
Total	4.897	76				3.072	44				1.825	32			

Table C3-2S

Grade 3
Ordering Two- and
Three-digit Numbers
S-F

Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	44	.892	.165	21	.881	.170	23	.902	.164
	Control	38	.796	.301	25	.800	.306	13	.789	.304
F	Experimental	41	.608	.251	20	.526	.258	21	.687	.223
	Control	52	.565	.258	26	.613	.257	26	.516	.254
S-F	Experimental	41	.288	.268	20	.349	.286	21	.230	.243
	Control	38	.218	.358	25	.178	.364	13	.294	.348

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	Combined SS	df	MS	F	p	Falk SS	df	MS	F	p	Orchard Ridge SS	df	MS	F	p
Mean	5.105	1	5.105	51.50		2.900	1	2.900	26.30		2.205	1	2.205	26.85	
Groups	.099	1	.099	1.00	.322	.328	1	.328	2.97	.092	.033	1	.033	.40	.530
Within Groups	7.632	77	.099			4.742	43	.110			2.628	32	.082		
Total	12.835	79				7.970	45				4.865	34			

287

Table C3-26

Grade 3
Ordering Two- and
Three-digit Numbers
W-F

Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
W	Experimental	41	.750	.280	20	.775	.228	21	.726	.325
	Control	49	.689	.313	25	.810	.253	24	.563	.323
F	Experimental	41	.608	.251	20	.526	.258	21	.687	.223
	Control	52	.565	.258	26	.613	.257	26	.516	.254
W-F	Experimental	39	.155	.317	20	.249	.269	19	.056	.339
	Control	49	.119	.284	25	.188	.300	24	.047	.253

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	1.599	1	1.599	17.91		2.080	1	2.080	25.27		.111	1	.111	1.29	.263
Groups	.028	1	.028	.32	.574	.042	1	.042	.51	.477	.001	1	.001	.01	.925
Within Groups	7.679	86	.089			3.539	43	.082			3.533	41	.086		
Total	9.306	88				5.661	45				3.645	43			

Table C3-27

Grade 3
Ordering Two- and
Three-digit Numbers
S-W

Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	44	.892	.165	21	.881	.170	23	.902	.164
	Control	38	.796	.301	25	.800	.306	13	.789	.304
W	Experimental	41	.750	.280	20	.775	.228	21	.726	.325
	Control	49	.689	.313	25	.810	.253	24	.563	.323
S-W	Experimental	41	.134	.263	20	.100	.249	21	.167	.278
	Control	35	.057	.338	24	-.010	.280	11	.205	.416

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	Combined SS	df	MS	F	p	Falk SS	df	MS	F	p	Orchard Ridge SS	df	MS	F	p
Mean	.740	1	.740	8.24	.005	.070	1	.070	.98	.328	1.033	1	1.033	9.48	.004
Groups	.112	1	.112	1.25	.268	.133	1	.133	1.87	.179	.010	1	.010	.10	.760
Within Groups	6.648	74				2.985	42	.071			3.269	30	.109		
Total	7.500	76				3.188	44				4.313	32			

Table C3-28

Grade 3
Basic Multiplication Facts
S-F

Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	43	.758	.251	21	.928	.127	22	.595	.232
	Control	38	.792	.233	25	.844	.220	13	.692	.233
F	Experimental	41	.477	.287	20	.464	.290	21	.490	.290
	Control	52	.522	.277	26	.622	.285	26	.422	.234
S-F	Experimental	40	.303	.314	20	.460	.295	20	.145	.253
	Control	38	.256	.224	25	.220	.216	13	.323	.232

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	6.102	1	6.102	81.25		4.812	1	4.812	74.72		1.528	1	1.528	25.53	
Groups	.043	1	.043	.58	.450	.639	1	.639	9.93	.003	.249	1	.249	4.17	.050
Within Groups	5.708	76	.075			2.769	43	.064			1.855	31	.060		
Total	11.853	78				8.221	45				3.632	33			

Table C3-29

Grade 3
Basic Multiplication Facts
W-F
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
W	Experimental	43	.416	.357	21	.556	.323	22	.281	.341
	Control	50	.493	.361	26	.734	.208	24	.233	.307
F	Experimental	41	.477	.287	20	.464	.290	21	.490	.290
	Control	52	.522	.277	26	.622	.285	26	.422	.234
W-F	Experimental	40	-.042	.422	20	.100	.375	20	-.185	.427
	Control	50	-.036	.366	26	.111	.266	24	-.196	.397

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	.135	1	.135	.88		.521	1	.521	5.16		1.599	1	1.599	9.47	
Groups	.001	1	.001	.01	.939	.001	1	.001	.01	.903	.001	1	.001	.01	.930
Within Groups	13.520	88	.154			4.444	44	.101			7.089	42	.169		
Total	13.656	90				4.967	46				8.689	44			

Table C3-30

Grade 3
Basic Multiplication Facts
S-W
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	43	.758	.251	21	.928	.127	22	.595	.232
	Control	38	.792	.233	25	.844	.220	13	.692	.233
W	Experimental	43	.416	.357	21	.556	.323	22	.281	.341
	Control	50	.493	.361	26	.734	.208	24	.233	.307
S-W	Experimental	42	.352	.292	21	.372	.336	21	.333	.246
	Control	37	.144	.282	25	.109	.227	12	.217	.374

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	5.121	1	5.121	62.03		2.407	1	2.407	30.22		2.788	1	2.788	31.52	
Groups	.858	1	.858	10.40	.002	.792	1	.792	9.94	.003	.103	1	.103	1.17	.288
Within Groups	6.356	77	.083			3.504	44	.080			2.742	31	.088		
Total	12.335	79				6.702	46				5.634	33			

Table C3-31

Grade 3
Basic Division Facts
S-F
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	43	.746	.266	21	.800	.274	22	.695	.253
	Control	38	.613	.280	25	.683	.295	13	.476	.192
F	Experimental	41	.290	.209	20	.300	.184	21	.281	.235
	Control	52	.299	.230	26	.397	.251	26	.202	.158
S-F	Experimental	40	.461	.259	20	.510	.275	20	.413	.239
	Control	38	.282	.259	25	.284	.282	13	.278	.217

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	10.903	1	10.903	162.70		6.643	1	6.643	85.32		4.271	1	4.271	80.21	
Groups	.629	1	.629	9.39	.003	.568	1	.568	7.30	.010	.144	1	.144	2.70	.111
Within Groups	5.093	76	.067			3.348	43	.079			1.651	31	.053		
Total	16.625	78				10.560	45				6.065	33			

293

Table C3-32

Grade 3
Basic Division Facts
W-F
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
W	Experimental	43	.392	.213	21	.461	.238	22	.327	.167
	Control	49	.399	.311	25	.551	.322	24	.241	.206
F	Experimental	41	.290	.209	20	.300	.184	21	.281	.235
	Control	52	.299	.230	26	.397	.251	26	.202	.158
W-F	Experimental	40	.100	.232	20	.170	.257	20	.031	.186
	Control	49	.093	.257	25	.155	.268	24	.029	.233

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	Combined SS	df	MS	F	p	Falk SS	df	MS	F	p	Orchard Ridge SS	df	MS	F	p
Mean	.830	1	.830	13.71		1.174	1	1.174	16.98		.040	1	.040	.88	
Groups	.001	1	.001	.02	.894	.002	1	.002	.03	.854	.000	1	.000	.00	.975
Within Groups	5.267	87	.061			2.971	43	.069			1.911	42	.045		
Total	6.098	89				4.147	45				1.951	44			

Table C3-33

Grade 3
Basic Division Facts
S-W
Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	43	.746	.266	21	.800	.274	22	.695	.253
	Control	38	.613	.280	25	.683	.295	13	.476	.192
W	Experimental	43	.392	.213	21	.461	.238	22	.327	.167
	Control	49	.399	.311	25	.551	.322	24	.241	.206
S-W	Experimental	42	.350	.222	21	.338	.252	21	.362	.194
	Control	36	.150	.260	24	.121	.253	12	.209	.275

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	5.184	1	5.184	89.76		2.225	1	2.225	34.87		3.093	1	3.093	60.75	
Groups	.775	1	.775	13.43	.001	.530	1	.530	8.30	.006	.180	1	.180	3.53	.070
Within Groups	4.389	76	.058			2.744	43	.064			1.578	31	.051		
Total	10.349	78				5.498	45				4.851	33			

295

Table C3-34

Grade 3
Multiplying a Two-digit
by a
One-digit Number
S-W

Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	43	.735	.276	21	.899	.184	22	.579	.260
	Control	38	.665	.257	25	.740	.210	13	.519	.283
W	Experimental	43	.349	.251	21	.292	.248	22	.403	.247
	Control	49	.286	.272	25	.395	.247	24	.172	.255
S-W	Experimental	42	.399	.355	21	.607	.331	21	.191	.239
	Control	36	.326	.206	24	.359	.193	12	.260	.223

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	10.413	1	10.413	119.17		10.153	1	10.153	143.15		1.538	1	1.538	28.22	
Groups	.102	1	.102	1.16	.284	.688	1	.688	9.69	.003	.037	1	.037	.69	.414
Within Groups	6.641	76	.087			3.050	43	.071			1.690	31	.055		
Total	17.156	78				13.891	45				3.266	33			

Table C3-35

Grade 3
Four-digit Addition/
Subtraction
S-W

Descriptive Statistics

		Combined			Falk			Orchard Ridge		
		n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
S	Experimental	43	.674	.196	21	.643	.177	22	.704	.212
	Control	49	.741	.204	25	.700	.236	24	.784	.159
W	Experimental	43	.821	.164	21	.849	.148	22	.795	.178
	Control	38	.789	.235	25	.766	.221	13	.833	.264
S-W	Experimental	42	.139	.195	21	.206	.197	21	.071	.172
	Control	36	.046	.248	24	.070	.260	12	.000	.225

(Scores given as percentages out of 1.000.)

Analysis of Variance

Source	SS	df	MS	F	p	SS	df	MS	F	p	SS	df	MS	F	p
Mean	.722	1	.722	14.83		.801	1	.801	14.81		.068	1	.068	1.85	.184
Groups	.166	1	.166	3.41	.069	.210	1	.210	3.88	.055	.039	1	.039	1.06	.312
Within Groups	3.699	76	.049			2.325	43	.054			1.145	31	.037		
Total	4.587	78				3.335	45				1.252	33			

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